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EDITORIAL.

ITEMS AND NOVELTIES.

Stevens' Institute of Technology—*Continued* from page 78). —Having completed the survey of the first floor, as described in our previous numbers, we will return to the west side of the building and enter upon the second floor from that direction. Passing from the stairway into room No. 10, which occupies the entire wing at that level, we find it to be fitted up as a chemical lecture room with every available appliance.

Thus, at C.C., and also in the adjacent corner not marked in the plan (see plate), are large cases for chemicals and chemical vessels; at E is an evaporating closet and sand-bath heated by steam; at S is a sink provided with hot and cold water, and also distilled water "laid on" by a block tin pipe.

In the lecture table T a pneumatic tank and stationary wash-basin S are placed, also an opening connected with a powerful draft, which removes downwards through the table all offensive fumes and smoke allowed to escape over it. To this table are also laid on, oxygen and hydrogen gases from large tanks in the basement, heavy conductors from the battery room for galvanic currents, steam, compressed air, and even vacuum from a Bunsen pump, and also, as a matter of course, ordinary illuminating gas in an abundant supply.

The seats for the students are arranged on platforms, and at the rear on either side of V V, which is not quite correct in size or position in the plate, are large closets containing, among other things, a full set of Hoffman's apparatus for illustrating the modern theory of chemistry.

Provision is here also made for a supply of oxygen and hydrogen gases, to be used in projections with the lantern, for which also a screen, that can be lowered at pleasure, is arranged in rear of the lecture table.

The small room 10[1] is a sort of chemical pantry, and is fitted on all sides with cases and drawers filled with glass and porcelain apparatus, such as are used in illustration of the lectures.

Passing into the main building, we first come, in room 11, to the department of mathematics, where we find an abundant supply of blackboards, and also cases containing the instruments commonly employed in "surveying."

The next room, No. 12, is that devoted to Mechanical Engineering. Here we find at one end, a lecture table supplied with all the conveniences of water, gases, steam, electricity, &c., requisite for the illustration of all mechanical devices, and all available wall space filled with cases containing models of the "elements of machines" and other related material.

The models and apparatus of this department are from Schröeder, of Darmstadt, and Salleron, of Paris; from the instrument makers of the Institute and from the Patent Office.

There are models of trusses and bridges; of the elements of machines, such as cams, gearing and cranks, and other methods of transmitting and modifying motion; of simple machines, as pumps, windlasses and pulleys; of motors, as wind-mills, water-wheels of various kinds, air, gas and steam engines.

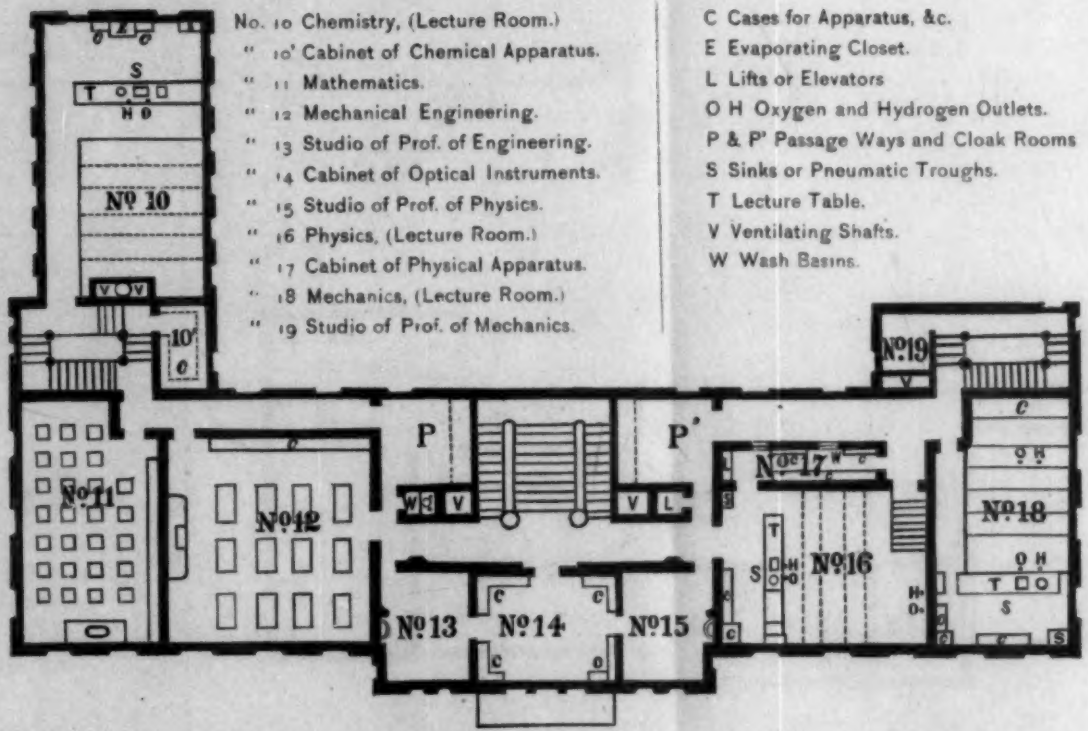
The collection of models of Steam Machinery is very full and complete. It includes historical models, exhibiting the successive improvements from the "Ælopile" of Hero (250 B.C.) to the most modern form of the steam engine; also *sectional* models of the principal of the common types of both engine and boiler, and representations of the usual modifications of their more important parts and appurtenances.

Beside the large collection already in hand, orders are still outstanding for considerable addition, and the workshops of the Institute, while enabling the student to become practically acquainted with

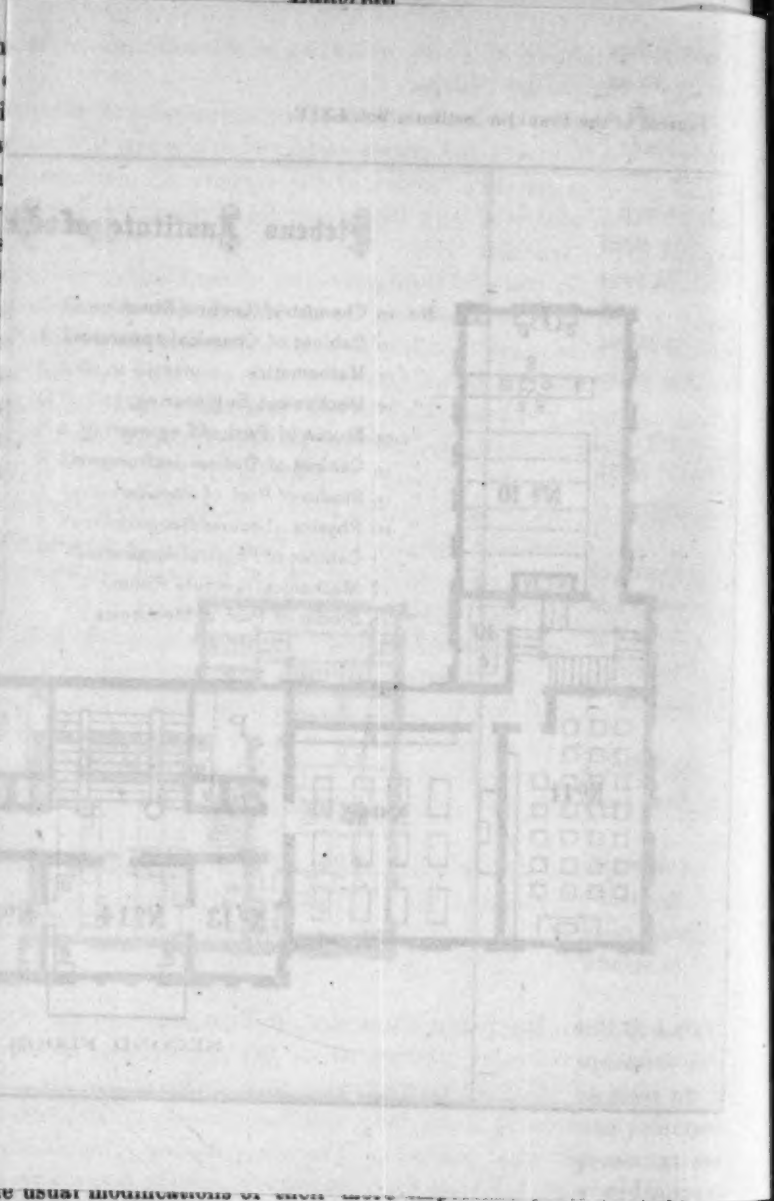
Stevens Institute of Technology.

No. 10 Chemistry, (Lecture Room.)
" 10' Cabinet of Chemical Apparatus.
" 11 Mathematics.
" 12 Mechanical Engineering.
" 13 Studio of Prof. of Engineering.
" 14 Cabinet of Optical Instruments.
" 15 Studio of Prof. of Physics.
" 16 Physics, (Lecture Room.)
" 17 Cabinet of Physical Apparatus.
" 18 Mechanics, (Lecture Room.)
" 19 Studio of Prof. of Mechanics.

C Cases for Apparatus, &c.
E Evaporating Closet.
L Lifts or Elevators
O H Oxygen and Hydrogen Outlets.
P & P' Passage Ways and Cloak Rooms
S Sinks or Pneumatic Troughs.
T Lecture Table.
V Ventilating Shafts.
W Wash Basins.



SECOND FLOOR.



tenances.

Beside the large collection already in hand, orders are still outstanding for considerable addition, and the workshops of the Institute, while enabling the student to become practically acquainted with

working machinery, will also, by adding to the collection of models, be very useful to the College.

This department possesses and is collecting samples of the various kinds of woods, stones and metals employed in the arts in their various stages of preparation for use, of the commercial lubricating oils, and of other materials, with the properties of which the engineer is expected to be familiar.

The use of the powerful testing machine of the Camden and Amboy repair shops has been generously tendered to the Institute for experimenting upon strength of materials; and apparatus made by Salleron has been imported for investigations of their elasticity and resilience. Other machinery is being built by the Institute with which to make unusually accurate and extended researches in this important field.

For determining the resistance of machines and the power of prime movers the Prony Dynanometrical Brake, the Recording Spring Dynamometer, Emerson's Portable Lever Dynamometer, and a number of steam engine indicators, among which are Richards' Indicator and the McNaught, of several sizes, have been obtained.

Among the drawings are complete sets, representing the hulls and engines of steam vessels, locomotive and stationary engines, and machinery of various kinds. The larger proportion are manuscript drawings, made for actual construction in the drawing rooms of their designers; some are the product of the labor of the students, and others are lithographed drawings, obtained by purchase at home and abroad.

No. 13 is the study of Prof. Thurston, who occupies the chair of Engineering, and contains his fine professional library and many objects of interest in the same direction.

(To be continued.)

The Union Railroad Company's Tunnel.—At the present time there are in course of construction, two tunnels beneath the city of Baltimore. That of the Baltimore and Potomac Railroad Company will be about 1½ miles long, and has recently received description in the technical journals. The other, by the Union Railroad Company, has for its object the connection of all the roads with tide-water, and also to afford a passage around the city by steam-power, thus dispensing with the hauling of goods and passengers through the streets with horses.

The following facts, together with a tracing of the work, we have

obtained through the courtesy of the Assistant Engineer, Walter F. Elmer.

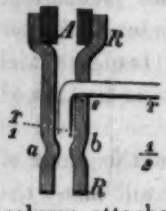
The Union tunnel is being constructed under the bed of Hoffman street, which runs east and west. From façade to façade it is 3,400 feet long. It is formed of a semicircular arch of five brick rings, and an invert of four bricks. In some places, where a good rock bottom exists, the invert is dispensed with.

About 450 men and 90 horses are engaged on the work. The material, which is mostly sand, is excavated to the whole depth of the cut; the arch is then built and the material replaced over it. The tunnel, with the exception of about 360 feet which is being drifted, is worked in this way:

About one-third of the arch is finished at the present time (July 22d), and the whole tunnel is expected to be finished and ready for trains by next January.

The arch is being built in sections of 50 feet in length, and these sections are being constructed at five or six points simultaneously.

A New Form of Water Air-Pump.—Herr. C. Christiansen suggests a very simple method of arranging a Bunsen pump* for use in filtration, etc., in the laboratory. The accompanying figure illustrates



the suggested modification. R, R is a thick walled caoutchouc tube, and is firmly attached about the water-pipe A. With a red hot needle an opening is pierced through R R at e, and into this the bent glass tube r r is passed. If the water is now allowed to flow through A, but little suction is exerted at r; a mercury column attached, as is usual in other forms of the water air pump, shows an elevation of not more than 1″. If, however, the tube R R is pressed together, as at a b, the quicksilver rises at once to 26″–27″; a proof that by this device an almost complete vacuum can be obtained. To obtain the best effect, much depends upon narrowing the tube at the proper place, for the great increase in effect manifests itself only when this is done at a few points. It is, however, only necessary to experiment until the desired conditions are produced, and then to permanently narrow at the proper point.

An Expansion Steam Trap.—The device shown in the accompanying illustration is one of the class in which the expansion and

* Pogg. Annalen, cxlvi, 155.

contraction of an inner tube, in excess of that of an outer one, caused by the difference in temperature of the two tubes, so operates a valve as to permit the water to escape from the inner tube, and to close the valve when steam only is present.

A is a socket to be connected to the termination of a steam-heating coil, and into this socket are screwed the ends of the outer tube, B, and inner tube, D, the former being screwed into a socket, E, and the tube D passing through a stuffing-box, *a*, formed within the said socket, to which is secured a casing, F, having an outlet for the escape of the water. The space, G, between the two tubes, is filled with a non-conducting material. The outer end of the tube D is furnished with a valve, H, adapted to a seat, I, both being contained within the casing, F; strong spiral springs, J, also within the said casing, tend to maintain the legs, *b*, of the seat, in contact with the end of the socket, E, as shown. As long as steam remains in the tube D, the heat will expand the latter, and the valve H will remain in contact with the seat I, which yields to the expansion; the valve H thus remaining closed to its seat, no matter what may be the difference in length between the tubes. Owing to this yielding valve, the inner tube cannot be buckled or strained, a result which is frequent when the valves in this class of steam traps bear against fixed seats. The presence of water in the tube D will cause the latter to contract, and the valve H will be consequently drawn inward, followed by its seat, until the legs, *b*, of the latter come in contact with the end of the socket E, when, owing to the continued contraction of the inner tube, the valve will leave its seat and permit the water to escape.

This form of trap is the invention of Mr. John G. Baker, and he claims for it, amongst other things, the following advantages: that it will operate in a vertical as in a horizontal position; that, being self-regulating, it requires no attention, as high or low pressure does not affect its working.

Coal-Cutting Machinery.—The time when the manual labor now universally employed in the working of coal shall be substituted by machinery, with the aid of which the quantity of production may be increased and the cost of production diminished, seems not so far distant. The operations in the coal regions, both here and abroad, are regularly assuming vaster proportions, and in our own mines this increase from a number of causes bids fair to be unprecedented in the next decade. Along with the demand for increased production comes also the absolute necessity of freeing this important industry from the troublesome and damaging influences of strikes and similar combinations of the workmen, which can at least be partially checked by the introduction of machinery by which a large proportion of manual labor employed may be dispensed with. We already hear of the successful introduction of several machines for cutting coal in the Scranton Region of Pennsylvania, the operation of which is so satisfactory, both in point of increased production, less waste, and greater economy as compared with hand labor, that the extension of their employment elsewhere may be looked for in the near future.

From England also comes the information that a similar experiment has been made. The Wigan and Western Company have tested for some time a machine of this kind, with rotary cutters, worked by compressed air, in a seam of exceptional hardness, and with satisfactory results.

The Manufacture of Beet Sugar.—The Legislature of New Jersey, at its last session, with a view of encouraging the introduction and growth of this important branch of industry in their State, passed the following act, which recommends itself for repetition elsewhere:

1. Be it enacted by the Senate and General Assembly of the State of New Jersey, that for the term of ten years next, after the passage of this act, all the machinery, buildings, real estate, and all other property owned by any individual or individuals, corporation or corporations, organized under any law of this State, and used exclusively in the manufacture of beet sugar, are hereby exempted from taxation for any purpose whatsoever; provided that this exemption from taxation shall not apply to lands upon which beets are raised for the purpose of manufacture.

2d. *And be it further enacted*, That the stock of any incorporated company engaged exclusively in the manufacture of beet sugar in this State, held and owned by any individual or individuals, shall be ex-

empt from taxation for any purpose for the time specified in the first section of this act.

3d. *And be it enacted*, That this act shall take effect immediately, and be in force from and after its passage.

In order that a just notion of the importance of intelligent legislation upon this subject may be obtained, it may be of service to give in general terms a statement of the present extent of the beet sugar industry in the various European countries, where it has been encouraged for years, and now returns no inconsiderable revenue to the respective States.

Country.	No. of manufac ories.	Beet — quantity consumed in cwt	Sugar production in cwt.	Av'g production of one establishment.
France	434	82,850,000	5,800,000	190,915
Germany	266	51,495,494½	4,319,640	172,619
Russia	300	42,400,000	3,792,000	141,334
Austria	212	42,300,000	3,400,000	199,530
Belgium	106	14,200,000	1,000,000	131,482
Holland	18	2,143,000	150,000	119,060
Sweden	4	770,000	61,600	192,500
	1370	236,158,404½	18,523,240	173,380

Combining Iron and Steel.—Mr. E. Wheeler, of Philadelphia, has patented a process of combining iron and steel, which possesses certain novel points. The product is claimed to be equally serviceable for the most varied uses, and to possess all the desirable qualities anticipated of such a successful combination.

The principle of the invention consists in bringing the two metals to a welding heat in one "pile" and simultaneously, and then manipulating them by rotary motion.

The main difficulty experienced in effecting such a combination, the inventor very reasonably states to be that steel, in order to be heated to the welding point of iron, will be injuriously affected by the high temperature, or become what is technically called "burnt." The use of fluxes may obviate the difficulty to a great extent, but their use is objectionable on the score of economy and the tediousness of the operation. In the plan under consideration the combination is effected, and the steel protected from the oxidizing effect of the heating by enclosing it in an iron case, made as nearly air-tight as possible.

The applications of the invention are stated as follows:

1st. The reduction of steel into an iron-coated steel slab, plate or bar, in which steel predominates.

2d. The production of steel centred iron, in which iron is the principal metal used; and, 3d. Combination proper, in which the steel is so proportioned and placed as to endure wear and support strain.

In the utilization of steel scrap, and in the manufacture of rails, peculiar advantages are claimed; indeed, certain journals of high standing in the metallurgy of iron and steel have already spoken of the invention in glowing terms.

As an illustration of the plan of one of the proposed applications of the process, we can do no better than to quote from the description of the inventor. The process is so extremely simple, that if the results obtained even partially verify the strong claims made in its favor, it cannot fail to become of great importance, and worthy of the prompt attention of workers in iron.

"In the rapid and economical manipulation of 'scrap' steel of any kind by this process, the advantage over the old methods is so great as to leave no question of competition. Cast steel scrap, which is now only worked by re-melting, when encased in iron, as described above, can be rolled into *finished bar at one operation*, and even Bessemer steel scrap, which has hitherto defied every attempt to weld it up into a sound mass, is by this process re-worked from any size of 'pile' into any desired shape of rail, bar or plate, as sound and homogeneous as from the original ingot. The great importance of this feature of the invention to the railroad interests of the country will be obvious to all those managers who have adopted steel rails, or who have contemplated so doing, and have felt that sooner or later they must meet the question, 'What shall we do with Bessemer scrap?'"

The Utilization of Waste Coal.—Our readers will recall the process of Mr. E. F. Loiseau for utilizing waste anthracite, upon which a detailed report of the Committee of Science and Arts of the Institute was published in the February number of the last volume of the Journal.

There seems now to be some prospect that the plan of Mr. L. will have at least a fair trial upon a large scale; seeing (as we are credibly informed) that the Lehigh Coal and Navigation Company have entered into negotiations with the inventor for the purpose of testing the merits of the process. A large establishment at Nesquehoning, Pa., erected at great expense some time since by a Philadelphia company, with the same object in view, and afterwards abandoned from the failure of the enterprise, has been purchased by the

Company; the machinery is being at present altered, under the direction of Mr. L., to render it suitable for his process; and in a month or more the manufacture and experimental trials of the artificial fuel will commence.

New Method of Printing on Cloth.—Mr. E. Vial* proposes to first impregnate the tissues to be printed, with a solution of nitrate of silver, or of some other metallic salt, which, when brought into contact with zinc or copper, will be reduced to the metallic state. His design is in this way to print upon the impregnated tissue, with a zinc (or copper) pattern. The result of this process is that wherever contact is made between the metal plate and the cloth, there is formed a metallic precipitate of silver (if the nitrate of silver was used to saturate the tissue), which is firmly fixed upon it. The color of the precipitated metal may be varied, according to the strength of solution used, from a brilliant grey to a deep black. The color is declared to be very fast, withstanding acids, alkalies or soaps.

A New Fuel for Locomotives.†—The Russian Steamship and Railway Company announces that it has found the use of naphtha for steam generation, with locomotives, very advantageous. The material employed by the company is the crude oil from the Caucasian and Volga regions, and, compared by weight, the amount consumed was about one-half that of coal. The arrangement for burning naphtha is stated to be of such a nature that no difficulty will be experienced in substituting one for coal consumption in place of it, should it be found desirable so to do.

Mineralogical.—Zirkel has given the feldspathic mineral bytownite (classed with the lime soda feldspars), an examination, and with the aid of the microscope has succeeded in determining that, so far from being a simple species, it is made up of at least four distinct minerals, to-wit, a triclinic feldspar, a green hornblende, quartz (?), and granules of magnetic iron.‡ Bytownite is therefore a thing of the past.

M. Helland has observed a pseudomorph of mica after garnet. The garnet is an iron-alumina variety, from near Arendal, Norway, and occurs in trapezohedrons of red-brown color in a vein stone of feldspar

* Comptes Rendus, June 10th, 1872.
† Illustrirte Gewerbeze.
‡ Poggendorff, Annalen.

and mica. Some specimens, while completely retaining their form, have changed completely to a green potash-mica; others still retain a nucleus of unchanged garnet.

The same author has observed a pseudomorph of steatite in the form of augite, from Snarum, the locality celebrated for the pseudomorphs of serpentine after olivine.

It might also not be altogether uninteresting to note an observation by the writer of a new locality for the occurrence of pseudomorphs of mica after andalusite, namely, at North Conway, New Hampshire. The occurrence is in an extremely fine-grained, thinly-laminated mica-schist, and the crystals of andalusite, quite large (some as large as 3 inches), and abundantly distributed throughout the rock, giving it a contorted structure, are completely changed to a brilliant white mica. No analysis of the latter was made.

Prof. Story-Maskelyne has added to the list of mineral species a new crystalline variety of quartz, to which he gives the name of Asmanite. It is a meteoric mineral, and was detected amongst the constituents of a meteorite from Breitenbach in Bohemia, and now in the British Museum. Sp. gr. 2·245, resembling in this particular the lately discovered tridymite of Von Rath (sp. gr. 2·3). Prof M. has determined Asmanite to crystallize in the orthorhombic system, H. 5.5. It is associated with enstatite, chromite, triolite and nickeliferous iron.

Mr. Theo. D. Rand has communicated to the writer the following information relative to the genesis of the large deposits of carbonate of zinc at the famous mines in the neighborhood of Bethlehem, Pa.

. . . . . "On a visit to the zinc mines at Friedensville, Pa., I noticed the occurrence of sulphate of zinc (goslarite) in quite large quantities, as an efflorescence upon the walls of the open workings. The existence of this mineral (derived, doubtless, from the sulphide of zinc by oxidation) in juxtaposition to limestone rocks, explains, in a most simple and satisfactory manner the formation, by double decomposition, of the carbonate of zinc, which is so valuable an ore at this locality."

Kengott proposes* to class both of the interesting minerals lately described by Roepper (viz., a zinc-olivine and a manganese-dolomite) as distinct mineral species, and proposes to call the first stirlingite, from the locality of its occurrence; and the second, in honor of its discoverer, roepperite. Some confusion in regard to the names of the minerals in question is likely to occur, in view of the fact that Prof. Brush, in his recent supplement to Dana's Mineralogy, has

attached the name roepperite to the more interesting and important of the two, namely, to the zinc-olivine. In the August number of the "American Journal of Science," the regret is very properly expressed that Roepper's name should not be reserved for the latter mineral.

A. Weisbach has described a new uranium mineral under the name of Zeunerite. It occurs in the erz-gebirge of Saxony. In physical property it resembles the copper uranite very closely in lustre, color, crystallization and cleavage, and indeed in everything except specific gravity, which is only 3·2.

It was found upon analysis to contain no phosphoric acid, but, instead of this, its representative, arsenic acid. The two minerals are therefore to be regarded as isomorphous, the new mineral being an arsenate of copper and uranium.

L. J. Ingelström describes, under the name of manganophyll, a new variety of mica, containing 21·40 per. cent. of manganese, from Filipstadt, in Sweden. In color it is bronze to copper-red, and gives a pale red powder. It is completely decomposed by hydrochloric acid, leaving its entire quantity of silica behind in the form of the original laminæ.

Microscopical—A Life Slid e.—The accompanying engravings represent front and side views of a form of life slide for the microscope, designed and used with much success by Mr. D. S. Holman. It is constructed to retain the greatest quantity of material under the smallest cover glass, and is designed to be used with the highest powers of the microscope for studying the Bacteria, Vibriones and other very low forms of life.

The slide consists, as will be seen from the cuts, of a central polished cavity, about which is a similar polished level; and from the bevel outwards extends a small cut, the object of which is to afford an abundance of fresh air to the living things within, as well as to relieve the pressure, which shortly would become so great, from the evaporation of the liquid within, as to cause the destruction of the cover glass.

No special dimensions are stated for the central cavity. The bevel is usually $\frac{1}{8}$ in. in diameter (the cut is $\frac{3}{4}$ of nat. size); the small canal

is cut through the inner edge of the bevel or annular space, outwards, for the purpose named above.

It is found, upon enclosing the animalculæ, &c., that they will invariably seek the edge of the pool in which they are confined, and the bevelled edge permits the observer to take advantage of this disposition; for when beneath it, the objects are within range of the high-power glasses.

Another very important feature in the device is the fact that a preparation may be kept within it, for days or weeks together, without losing vitality, owing to the simple arrangement for supplying fresh air.

We have repeatedly had the opportunity of witnessing the use of this slide, and are convinced that nothing of the kind has yet been devised which can equal it in excellence, either for observing, or generating the lower forms of life.

Scientific Meetings for the Year.—The twenty-first annual meeting of the American Association for the Advancement of Science will take place at Dubuque, Iowa, commencing August 21st, 1872, at 10 o'clock A.M. The Association meets this year under the presidency of Prof. J. Lawrence Smith. From the circular of the Local Committee we learn that, on the evening of Wednesday, Aug. 21st, a formal reception will be extended to the Association by the Hon. W. B. Allison, Senator elect and Chairman of the Committee of Reception. After a response on the part of the Association, Prof. Asa Gray, the retiring President, will deliver his address, and give up his chair to his successor.

To judge from the local circular, the members attending will receive from the citizens of the city the most generous hospitality. Favorable arrangements have been made with the various railroad companies to reduce the expense of reaching the place of meeting from a distance; and, what will probably interest the members more than this, a number of excursions have been planned about the neighborhood, to examine the caves, mines, furnaces, and a number of interesting geological exposures.

A letter from Mr. E. D. Cook, one of the Secretaries of the Local Committee, contains the statement that Prof. Agassiz is expected to be present at the meeting. The many matters of scientific interest to the geologist and naturalist growing out of the Hassler expedition, cannot fail to attract the attention and influence the attendance of scientific men from all parts of the country.

On the other side of the Ocean, the British Association for the Advancenent of Science will open its sessions, at Brighton, on the 14th of August. The retiring President, Sir William Thompson, will transfer the Presidency to his successor, Dr. W. B. Carpenter.

New Explosive Mixture.—M. Violette has made the observation that by fusing together a mixture of the nitrate and acetate of soda, a white, hard mass is obtained, which, when heated to 350° C. (662° F.), explodes with violence. By plunging into the liquid mixture a lighted body, an explosion instantly follows.

Editorial Correspondence.

Technical News from Germany.

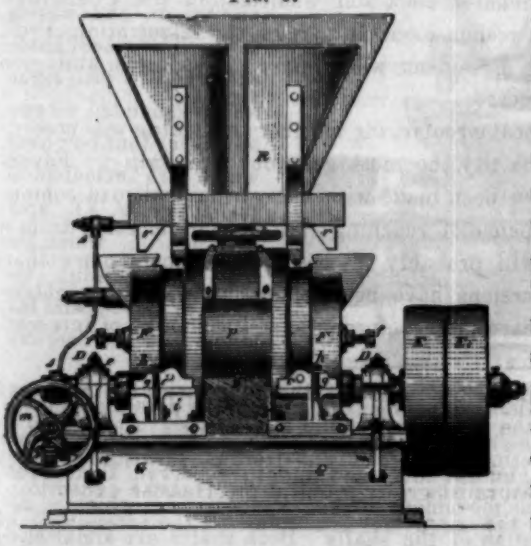
Leipzig, in July, 1872.

Editor Journal of the Franklin Institute:

Sir:—The technical journals have lately contained many communications upon the subject of grinding mills with vertical mill-stones. Having paid considerable attention to the improvement of mills of this description, I am able to furnish you with some exact information on the subject.

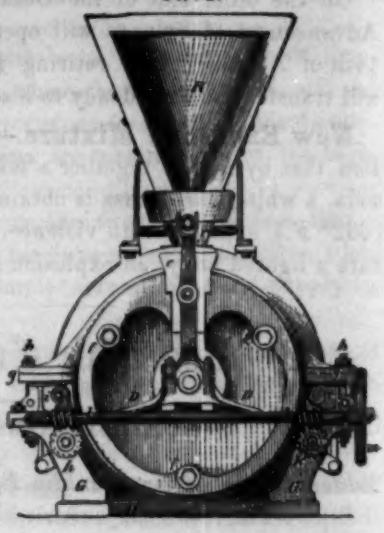
The figures 1, 2 and 3 represent views of mills of my construction, in which the parts will be recognized from the following description: The mill has three stones; of which the two outer ones, B B, are stationary, while the third and central one, A, is movable. This is attached to the shaft C, and the stones, B B, are placed in the cases, F F. Through these outer stones pass the feeding channels for the grain, which are connected with the

Fig. 1.



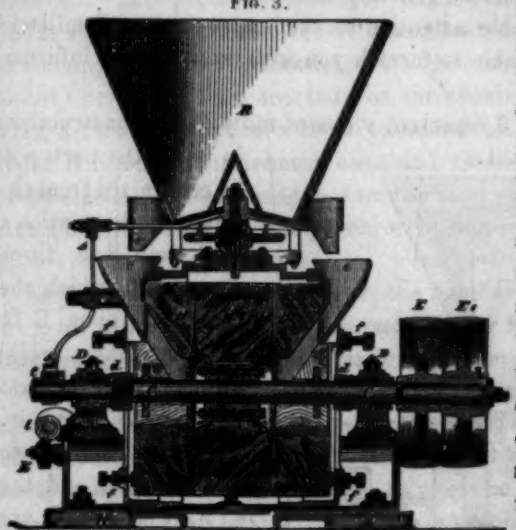
funnels, *c c*, in the cases, F F. A cast-iron plate, H, serves the purpose of a base to the mill. Upon this are the standards, G G, over which, at both ends, are placed the bearings, D D, which serve to support the mill shaft, C.

Fig. 2.



The most important problem which the constructor of these mills must solve, is to so arrange the two cases carrying the stationary stones, that they may be neared to or removed from the central rotating stone simultaneously and with equal movements, for only by this arrangement will the two grinding surfaces perform like service. For this purpose each of the standards is furnished with a shaft, on the outer ends of which are placed the screws which engage in the wheels, K K. The wheel-shafts are provided with right- and left-handed screws, and carry four box nuts, which are attached to the supports, *i i*, upon each pair of which the case for holding the stone is placed and fastened by the screws, *h h*.

Fig. 3.



In consequence of this arrangement of parts, it is possible to move the cases, F F, with the stationary stones, B B, to any distance from the running stone, A, and at the same time to preserve their even distance from it by the movement of the supports, *i i*, which is accomplished by the rotation of the shafts Both shafts are simultaneously put in motion, since the worms, *l l*, operating the toothed

wheels, K K, are on a common shaft. This is provided with a hand-wheel, *m*, by turning which the adjustment of the stone is effected.

The running stone, A, is firmly attached to the shaft, C; and may be secured in proper position by the screw-collars, *d d*. . . .

The mill is driven from the pulley E (the loose pulley E′ is also provided). Both pulleys are arranged so as to be detached, for convenience in case the mill need to be taken apart for repairs.

The grain is fed into the hopper, R, and after passing through *r r*, and the funnels, *c c*, reaches the grinding surfaces. The shoes, *r r*, are given a shaking motion by the lever, *s*, and the eccentric, *e*. The quantity of feed is regulated by raising or lowering the shoes from hand-wheel, *b b*.

In order that the mill may be readily taken apart for the purpose of sharpening the stones, the bearings, D D, as well as the stone cases, F F, are so attached as to permit of their being removed. To assist in the removal of the stone-cases, F F, together with the stones B B; openings, *c c*, are made in the plates, *g*, which permit of the application of a crane for the purpose.

The mills are built of two sizes: for stones of 500 and for those of 800 millimetres in diameter. The following resumé will indicate the advantages to be derived from this form of mill:

The work of the mill, estimating from the grinding surfaces, is doubled; and it is possible, with this construction, to use much smaller stones than are necessary in horizontal mills, at the same time affording quite as great an amount of grinding surface, and quite as great a production of meal, as the latter.

Suppose, again, that we have a vertical and horizontal mill of equal producing capacity. It will be found that the former will require much less power to run it than the latter, from its more compact form and its much lighter weight.

The putting up of a vertical mill is very simple. It is finished in the machine-shop, and needs only to be fastened to the floor with four screws in order to be ready for operating. In addition to this, one story of the mill building may be saved by its use, seeing that the space required in horizontal mills for the wheel work is here not required, and a conveyer for transporting the meal may be brought directly beneath the mill.

Another advantage of these mills, not to be undervalued, consists in the extreme simplicity of the method of transmitting the power required to operate them. Complicated and expensive trains of wheel

work are unnecessary, and a simple, relatively small shaft, placed at a level with, or over, or under the mill, will answer the purpose. Cooling devices are found to be unnecessary, since but little heating of the meal occurs, owing to the construction. The product, too, is, from this cause, found to be improved for storage.

The amount of attention required with the vertical mill is considerably less than with the old form, respective both of the running and repairing.

Experiments with this form of mill have been made in the grinding of cements, heavy spar, &c., and have afforded very satisfactory results.

In addition, when the fact is taken into consideration that, with equal producing capacity, the vertical mill is considerably cheaper than the horizontal, the following summary of advantages may be arranged:

1. Large duty, at least equal to the best constructed horizontal mills.
2. Economy of power.
3. Simple transmission.
4. No cooling apparatus.

} Therefore economy of space, capital, and in cost of operating.

5. Small first cost.
6. Small mill building necessary, lessening first outlay.
7. Ease of repairing and sharpening stones, and therefore economy of labor.

W. H. UHLAND, *Engineer.*

(To be continued.)

A Solvent for Shellac.—Dr. I. Walz describes the following process for obtaining a neutral solution of shellac in water.

The shellac is broken up and covered with a concentrated solution of carbonate of ammonia, and boiled upon the water-bath until the ammoniacal smell has disappeared. More of the solution is added, and the boiling is continued until the shellac forms a coherent, sponge-like mass. The carbonate of ammonia is then expelled by further boiling, and the mass will readily dissolve by pouring boiling water upon it. A kind of soap will be found floating on the surface, which may readily be removed by straining. The solution, brought on paper, cloth, &c., dries rapidly, and leaves a thin, lustrous and adherent film of shellac behind.

Civil and Mechanical Engineering.

STEAM-BOILER WATERS AND INCRUSTATIONS.*

By Dr. Joseph G. Rogers, of Madison, Ind.

All natural waters contain more or less mineral matter. This is acquired by contact with the earth's surface, and by percolation through its soil and rocks. It consists principally of carbonates of lime and magnesia, sulphate of lime, and chloride of sodium, in solution, and clay, sand, and vegetable matter, in suspension. The many other saline ingredients found in various waters exist in very small proportions, are generally very soluble, and therefore have no relation to the utility of waters in boilers. Of the above-mentioned salts, the carbonates of lime and magnesia are only soluble when the water contains free carbonic acid—consequently the waters of rivers, lakes, &c., contain them in less quantities than those of wells, springs, and creeks, owing to the precipitation caused by the spontaneous evolution of the solvent on exposure to air, heat, and light. Our American rivers contain from 2 to 6 grains of saline matter in the gallon, in solution, and a varying quantity in suspension, generally exceeding 10 grains. Well and spring waters hold but little in suspension but a quantity of the dissolved salts, varying from 10 to 650 grains in the gallon. When such water is boiled the carbonic acid is driven off, and the carbonates, deprived of their solvent, are rapidly precipitated in a finely crystallized form, tenaciously adherent to whatever they may first fall upon. Sulphate of lime requires 500 parts of water for its solution, and as the water evaporates supersaturation occurs, and the salt is precipitated in the same form and with the same adherent quality as the carbonates. Chloride of sodium and all the other more soluble salts are precipitated by the same process of supersaturation, but, owing to their greater solubility, much more evaporation is required. All suspended matter gradually tends to subside. This combined deposit, of which the carbonate of lime usually forms the greater part, remains adherent to the inner surface of the boiler, undisturbed by the force of the boiling currents. Gradually accumulating, it becomes harder and thicker, till it is as dense as porcelain,

* Abstract of a paper read before the American Association for the Advancement of Science, at Indianapolis, 1871.

though tougher, and at length may obtain such a thickness as to prevent the proper heating of the water by any fire that can be placed in the furnace. The high heats sometimes necessary to heat water through thick scale, will sometimes convert the scale into absolute glass by combining the sand with the alkaline salts composing it. The evil effects of the scale are due to the fact that it is relatively a non-conductor of heat. Its conducting power compared with that of iron is as 1° to 37·5. Consequently more fuel is required to heat water in an incrusted boiler than in the same boiler if clean. A scale $\frac{1}{16}$th inch thick will require the extra expenditure of 15 per cent. more fuel. This ratio increases as the scale is thicker. Thus when it is $\frac{1}{4}$ inch, 60 per cent. more fuel is needed; $\frac{1}{2}$ inch, 150 per cent., &c. Abstractly, then, to raise water in a boiler to any given heat, the fire-surface of that boiler must be heated to a temperature according with the thickness of the incrustation in an increasing ratio. To illustrate —to raise steam to a pressure of 90 lbs., the water must be heated to about 320° F. In a clean boiler of $\frac{1}{4}$ inch iron this may be done by heating the external surface of the shell to about 325°. If $\frac{1}{2}$ an inch of scale intervenes between the shell and the water, such is its non-conduction that it will be necessary to heat the fire-surface to about 700°, almost low red heat. Now the higher the temperature at which iron is kept, the more rapidly it oxidizes, and at any heat above 600° it very soon becomes granular and brittle, and is liable to bulge, crack, or otherwise give way to the internal pressure. This condition predisposes the boiler to explosions, and makes necessary expensive repairs. Again, it is readily seen that the presence of scale renders slower and more difficult the raising, maintaining and lowering of steam.

To obviate the evils arising from incrustation, many methods have been devised to prevent and remove it. For this purpose picking, scraping, cleaning, &c., are very generally resorted to. Such is its toughness and tenacity, however, that this only partially succeeds, and is moreover expensive in time and money, since it is generally necessary to lose a working day in the operation. Various mechanical contrivances have been introduced, intended to intercept the precipitated saline matter from the supply water on its passage through the heating apparatus. They consist essentially of a series of obstructions to the flow of the water. After it has been heated almost to boiling by the exhaust steam, the carbonates are precipitated, and subside upon the shelves, straw, and other obstructions, over which the

water flows. This plan, however, only partially fulfils the purpose, since it only intercepts a portion of the carbonates and suspended matter. The soluble salts all pass on into the boiler, and a great portion of the dissolved carbonates also, which cannot be precipitated during the short passage through the heater. The scales form more slowly, but as surely. It is impossible to make such contrivances completely efficacious. No mechanical arrangement will suffice. To chemistry alone must we look for the desired means. For a long time simple chemical means have been used in an empirical way with some success. The *modus operandi* of some of these I will notice. Starchy matters—such as Indian corn, potatoes, oil-cake, &c.—prevent scale only by enveloping the precipitates with gelatinous matter, thus lessening their weight, causing them to float, and obviating their agglutination into solid masses. This application, however, tends to cause foaming or frothing of the water, making it impossible to determine the quantity in the boiler, and hence is objectionable.

Molasses, fruits, cider, slops, vinegar, cane-juice, and a variety of other things, containing more or less acetic acid, placed in the boiler, convert the carbonates into soluble acetates. The sulphate of lime remains unaltered, however, and the iron being as much open to the attacks of the acid as the saline matter, the boiler is slowly but surely damaged.

Oak, hemlock, and other barks and woods operate by means of the tannic acid therein. Various extracts, such as catechu, logwood, &c., very rich in tannin, are also used. Tannic acid decomposes the carbonates, but, unlike the acetates, the resulting tannates are insoluble. Their specific gravity, however, is low; they float in the currents of ebullition, and, having no tendency to adhere, do not agglutinate into a mass, and cannot form a scale. The sulphates and chlorides are not acted upon at all by the tannic acid, and will incrustate notwithstanding its presence. Tannin, as offered in the above-named agents, is left free to act upon the iron, and will, after a time, exhibit its damaging effects on the boiler.

The fixed alkalies are much used for this purpose, in the various forms of lye, ashes, carbonate of soda, caustic soda, potash, &c. These agents decompose the sulphate of lime, sulphate of soda or potash and carbonate of lime being the results. The first is held in solution, the latter is precipitated, but in larger crystals, which do not form so refractory a scale as ordinarily. The carbonates of lime and magnesia are also precipitated by these agents, the free carbonic acid being

taken to form carbonates or bicarbonates of soda or potash; the chlorides are not affected. This method simply modifies the form of the precipitate, and consequently the quality of the scale, without affording any means for its prevention, and therefore deserves but little attention. Ammonia and its carbonate have a precisely similar action, and the same objection stands against them. These alkalies have no chemical action upon the boiler, but rather tend to preserve it, inasmuch as they prevent the free carbonic acid from combining with the insoluble crust of oxide of iron (formed by contact with the water) to form a soluble carbonate of iron, which, being dissolved away from the iron, would leave a surface constantly exposed to fresh action. Chloride of ammonium is another means employed. This has its action only on the carbonates of lime and magnesia. The reaction produces carbonate of ammonia, which, being volatile, passes off with the steam, and chlorides of calcium and magnesium, both very soluble. This is an efficient way of removing old scale. Its only objection is the ammoniacal odor of the escaped steam.

The foregoing are methods in which a single agent is used. They are frequently combined with a view of obviating the mentioned objections. Starch, tannin and soda constitute the basis of most of these combinations. Crude petroleum is also used with reported partial success. The *rationale* of its action is not well understood, owing to the complexity of its chemical constitution. There are many proprietary compounds at present in use composed essentially of these elements, generally, however, with the addition of other things, introduced for the purpose of disguising their composition. Besides these, many other preparations are before the public which have been patented, all having a general resemblance, inasmuch as tannin, starch, and soda, are the principal ingredients, in some form. Gum catechu is most generally the tannin-bearing body; sal soda, the alkali; and flax-seed, oil-seed cake, bran, or coarse flour the starchy element. In most of those which I have examined these very useful agents have been simply mixed empirically, without regard to chemical laws, and they generally contain more or less free tannic acid, and a considerable amount of inert, insoluble vegetable matter, which tends to produce foaming, besides being useless. Besides these methods, in which the chemical agents are introduced directly into the boiler, others have been devised, in which the waters are depurated, by chemical means, before entrance into the boiler. Clark's process consists in the precipitation of the carbonates with milk of lime, the free carbonic

acid being taken up; the sulphate of lime remains in solution. Another method, proposed by myself, consists in converting the earthy carbonates into soluble chlorides by hydrochloric acid, and neutralizing the excess of acid by filtration through carbonate of baryta (witherite) in coarse powder. The soluble chloride of barium thus formed decomposes the sulphate of lime, chloride of calcium being kept in solution, and the sulphate of baryta being deposited insoluble. This method recommends itself for railway water stations, on account of its cheapness and simplicity.

Oxalic acid may be used very efficiently for the complete precipitation of all the lime salts as insoluble oxalates, but the expense might be a bar to its use. Tannic and acetic acids, the excess being properly neutralized by carbonate of soda, may also be used for tank depuration.

These tank methods, however, cannot influence to any great extent the scale already formed; and as the removal of this is as needful as its prevention, it is palpable that that method is best for general application which attains the complete removal, as well as prevention, by chemical means operating inside the boiler.

Having this end in view, the writer has proposed two processes: one consists simply in the introduction into the boiler of a sufficient quantity of the oxalate of soda to cause the immediate decomposition of the scale-forming salts as they enter the boiler, converting them into insoluble oxalates, which are precipitated as a mushy sediment, which has no tendency to form scale, and which may be blown out from the mud-receiver, or otherwise voided. In the other process tannate of soda is the agent, kept constantly present in the boiler in solution; it decomposes the carbonate of lime and magnesia as they enter, tannates being precipitated in a light, flocculent, amorphous form, so that they do not subside at all in the boiler, but are retained in suspension by the boiling currents until they find their way into the same receiver, when they settle into a loose, mushy mass, which may be easily blown out from time to time. The carbonate of soda formed in the reaction is retained in solution, becoming a bicarbonate by appropriation of the free carbonic acid in the water. This decomposes the sulphate of lime, the resulting sulphate of soda being retained in solution, and the carbonate of lime being acted upon by fresh portions of the tannate of soda as above. The constant presence of the alkali protects the iron from all action, either of the carbonic or tannic acids. The same reactions take place between the

tannate of soda and the already existing scale with like results, but more slowly, some weeks being generally required, in practice, in removing the deposit, if it exists in any considerable quantity.

Portions of scale are detached, from time to time, which may be removed at the usual cleanings, which should be made at short intervals, when possible, until the boiler is entirely clear of all incrustation, after which this will not be necessary. Extensive practical trial of this process for two years has demonstrated its utility for all varieties of boilers. It is economical, easy of application, and generally adaptable. It may be used in marine boilers as well as those using fresh water, since the marine scale is almost identical with that formed in boilers using ordinary waters, consisting almost entirely of the carbonates of lime and magnesia and sulphate of lime. The chloride of sodium, forms a mushy deposit, but is only incorporated in the scale to a slight extent.

HINTS ON MECHANICAL DRAUGHTING FOR APPRENTICES.

By J. Richards, M. E.

It has been claimed that draughting bears the same relation to mechanics that penmanship does to literature; a proposition that is entirely wrong. Geometrical drawing is not an artistic art; it is nearer to being a constructive, mechanical one. An artist may delineate an object without understanding its nature, but a mechanical draughtsman cannot make drawings of a machine unless he understands its functions and operation; at least he cannot make drawings that are reliable, or have any great value. Artistic drawing is addressed to the eye, geometrical drawing to the understanding. The art of making geometrical drawings must, however, include artistic skill; not in the sense of ornamentation, but to meet the standard of neatness and effect that has by common custom been assumed, and which conveys an idea of competent construction in the drawings, as it does in the machinery to which they relate.

The artistic part of the business is an easy thing to learn, and is rather to be guarded against than encouraged in the beginning. It is quite a secondary matter when compared with the knowledge of mechanics, that is indispensable to the draughtsman.

It is easy to learn *how* to draw, but it is difficult to learn *what* to draw. This the apprentice must keep in his mind, and his first efforts be directed to *how* to draw, of which we now come to speak.

Usually, the apprentice's first ambition, upon entering a course, is to begin to draw, and he should do so; he cannot begin too soon, if he begins right. It need not interfere with, but will assist in, other things. Therefore begin at once, finish each draught; have some definite subject when you begin, and complete it. Place upon its margin the date, with a memorandum of the conditions under which it was made, and preserve it. In after-life you will find yourself possessed of a record of your progress, and a memento that you would not for any consideration part with.

To begin with, procure a draughting-board, or, what is better, two boards, thirty inches wide and forty-two inches long, made from one and one-half inch lumber; this will dress to one and three-eighths inch thick, and withstand, if well seasoned, the dampness of the paper in mounting. Have the edges plane and square, without any ingenious devices for holding the paper; these things belong to amateurs and not to the workshop. This size, thirty by forty-two inches, will receive "double elephant" paper, which can be best fastened by pasting down the edges with mucilage, or by means of small copper tacks, if the paper is not to remain long, and the drawing not shaded.

Two boards are needed, so that one can be used for making sketches or details, to assist with the elevations upon the other. Sketches or details, drawn one-half or full size, assist greatly in making a drawing to a smaller scale. Besides, it is often necessary to construct diagrams as we go along, that should not go on the main sheet. It also will familiarize the learner with different scales at the beginning, the time when it is easiest learned. A good plan is to use a common rule when the drawings are one-half, one-fourth, or one-eighth size. It enables the draughtsman to assume a comparative estimate from the standard inches, and to realize, as he goes along, the actual size of pieces when drawn to a reduced scale.

Get a plain T square of pear wood, with the blade forty-four inches long, set on one side of, and not imbedded in the head, so that the set squares can pass the head when the work is near the edge of the paper. This very sensible plan of arranging a T square, for some reason, is not common, although it can scarcely help suggesting itself to any draughtsman who makes large drawings. A bevel square, that will set to angles, is also convenient, but not essential; in no case use a combination square, with a fixed and an adjustable head. Avoid all combinations in instruments, no matter what their character. They

are all like combinations in machine functions, generally just the opposite from what is wanted.

For set squares, hard rubber or gutta percha is the best material. Its dark color contrasts with the paper; it is smooth, resists moisture and does not wear as rapidly as pear wood, which is the next best material.

Two set squares of 30° angle, one ten and one five inches long on the perpendicular, and one 45° angle, five inches long on the perpendicular, will be sufficient.

Avoid fancy and elaborate sets of instruments. They are for amateurs, not engineers. Procure a few instruments, such only as are needed, and these of the best quality. Keep them clean and in perfect order. Never add anything until there is a positive need for it. As a rule, two pairs of compasses (one three and one-half inches and one five inches), two ruling pens, two pairs of spring dividers (one with points and one with pencil), a triangular box-wood scale, and a hard pencil, is about all that is needed for linear machine drawings.

There are, of course, various customs about these things, and various opinions respecting the use of instruments. In one large engineering firm within the author's knowledge the draughting is done mainly with parallel rulers, working from a centre line, without T squares; a plan that may have some advantages, but at the same time many more disadvantages than the established methods.

The compasses can be used both for penciling and inking; the only combination I can recommend in instruments, and even this is often inconvenient.

At the beginning, when "scratching" is likely to be a liberal item in the work, use Whatman's, or the very best web paper. If to be water shaded, Whatman's paper is the best.

Supposing now the boards, implements and paper to be at hand, the next process is to mount it. If the drawing is to be elaborate, or is to remain long upon the board, the paper should be pasted down. To do this, first prepare the mucilage, and have it ready at hand with some slips of absorbent paper about one inch wide. Dampen the sheet on both sides with a sponge, and then apply the mucilage along the edge, for a width of one-half inch; then set the edge of the board on the floor, so that it will lean against the desk at steep angles. In this position the paper can be applied without assistance. Then, by placing the strips of paper along the edge, and rubbing over them with some smooth, hard instrument, the edges are pasted firmly

to the board; the paper slips taking up a part of the moisture from the edges, which are longest in drying. If left in this condition, the centre would dry first, and the paper be pulled loose at the edges by contraction before the paste had time to dry. It is therefore necessary to run over the centre of the sheet with a wet sponge at intervals until the edges adhere firmly, when it can be left to dry, and will be tight and smooth. In this operation much depends upon the judgment of the learner, and much will be learned by practice. One of the most common causes of trouble in mounting is in not having the mucilage thick enough. When thin, it is absorbed by the wood or the paper, and is too long in drying. It should be as thick as it can be applied with a brush, and made from clean gum Arabic or Tragacanth. When a sheet is likely to be removed, and replaced, or when the amount and nature of the work upon it do not justify the trouble of paste-mounting, it can be very slightly dampened, and the edges fastened with small copper tacks, driven, say two or three inches apart. These tacks, when driven down, sink below the surface, and do not, like thumb tacks, offer an obstruction to the T square. Thumb tacks are of little use, except to fasten tracing paper or cloth in a temporary manner, and need hardly be provided by the apprentice in his outfit.

We now come to penciling, which requires more skill, really, than inking in the lines. The important points in penciling are to stop the lines where they should terminate, to keep the paper clean and free from plumbago, and to secure exactness in dimensions. Good pencil work is important, and is, indeed, essential to good draughting. It is the surest test of a neat draughtsman, and is, of course, more seen and criticised in shop practice than the finished work. The very finest pencils are none too good, and last enough longer than cheap ones, to pay for the difference in cost. For compass pencils, use the round leads without wood. If your instruments are not fitted for points of this kind, have it done, so as to avoid the annoyance of paper tubes and other contrivances to hold the leads. A new pencil by Faber, which receives these round points, that can be set out as they wear away, is convenient for drawing. The flat point cannot, of course, be made so well; but a round point is about as good in most cases for straight lines, while it offers a great convenience in making fillets and other free hand lines.

We are now ready to begin a drawing, but before commencing let us inquire whether there are not some principles that can serve as

landmarks as we go along, some rules of constant application, that will relieve the student of much care, and help to a better understanding of the matter in hand.

First, then, drawings of machinery consist of plans, elevations and sections. The plan is taken on a horizontal plane, a view on the top; elevations are views of the sides of the object, on vertical planes; and sections are views on bisecting planes cutting through the object.

Second: all drawings in true elevation or section are predicated on a flat plane, giving no dimensions except parallel to that plane.

Third: two elevations taken at right angles to each other fixes all points, and gives all dimensions for the parts of a machine that have their axes in these two planes; but when a machine is complex, or when several parts lie in the same plane, three or sometimes four views are needed to display it in a comprehensive manner.

Fourth: drawings must be made in reference to each process in the manufacture of the work, and are responsible not only for mistakes in dimensions, but for all unnecessary expense in forging, fitting, pattern-making and moulding.

Fifth: every "piece" that is laid down has something to govern it that we will term a *base*, some condition of functions or position that, if understood, will suggest its size, shape and relation to other parts. By this searching after a base for each and everything, we proceed upon principles, avoid errors, and maintain continually a test of what is done. Every wheel, shaft, screw or piece of framing should be made with a clear view of the functions it has to fill. There is always a certain train of reasons why such parts should be of such a size, have such a speed of movement, or a certain amount of bearing surface. These reasons or conditions may be classed as *expedient*, *important*, or *essential*, and will always be found in one or the other of these degrees.

This is the base alluded to; first get at the essential conditions, next consider the important, then the expedient, and so on. If our knowledge is sufficient to understand these conditions, it is evident that we need not make any mistakes in our plans and drawings. This matter will be considered in detail when we come to speak of making designs.

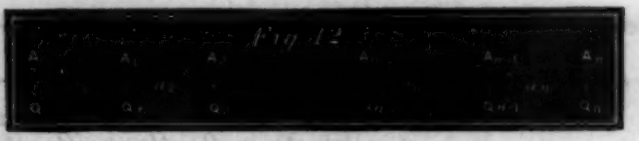
(To be continued.)

THEORY OF CONTINUOUS BEAMS.

By Jos. P. Frizell, C. E.

Continued from page 125.

We will now consider the case of a beam resting upon any number of supporting points.



In accordance with Fig. 12. Let

$A_o\ A_1\ \ldots\ A_n$ represent the points in which the beam is either supported or exposed to the action of isolated weights.

$a_1\ a_2\ \ldots\ a_n$ the respective distances between these points.

$Q_o\ Q_1\ \ldots\ Q_n$ the forces acting at the several points, which may be regarded as positive when they act from below upwards, as the resistances of the supporting points, and negative when they act from above downwards, as the pressure of isolated weights.

$\beta_o\ \beta_1\ \ldots\ \beta_n$ the angles at which the tangent to the elastic curve at the several points is inclined to the horizontal.

$y_o\ y_1\ \ldots\ y_n$ the vertical ordinates of the several points, which do not necessarily lie in the same horizontal line.

w the uniformly distributed weight per unit of length.

Consider a section of the beam normal to the elastic curve, in the opening $A_{n-1}\ A_n$, at a distance x from A_{n-1}. We have for the equation of moments at this section

$$E\,I\frac{d^2y}{dx^2}=\tfrac{1}{2}(a_1+a_2+\ldots a_{n-1}+x)^2\,w-(a_1+a_2+\ldots a_{n-1}+x)\,Q_o$$
$$-(a_2+a_3+\ldots a_{n-1}+x)\,Q_1-\ldots-(a_{n-1}+x)\,Q_{n-2}-x\,Q_{n-1} \quad (9)$$

or

$$E\,I\frac{d^2y}{dx^2}=\tfrac{1}{2}(a_1+a_2+\ldots a_{n-1})^2\,w+(a_1+a_2+\ldots a_{n-1})\,x\,w+\tfrac{1}{2}x^2\,w-a_1\,Q_o$$
$$-a_2(Q_o+Q_1)-a_3(Q_o+Q_1+Q_2)-\ldots a_{n-1}(Q_o+Q_1+\ldots Q_{n-2})$$
$$-x(Q_o+Q_1+\ldots+Q_{n-1}) \quad (10)$$

Integrating this equation, observing that when $x=o\ \frac{dy}{dx}=\tan\beta_{n-1}$, we have

$$E\,I\left(\frac{d\,y}{d\,x}-\tan\beta_{n-1}\right)=\tfrac{1}{2}\,(a_1+a_2+\ldots a_{n-1})^2\,x\,w+\tfrac{1}{2}\,(a_1+a_2+\ldots+a_{n-1})\,x^2\,w$$
$$+\tfrac{1}{6}\,x^3\,w-[a_1\,Q_o+a_2\,(Q_o+Q_1)+a_3\,(Q_o+Q_1+Q_2)$$
$$+\ldots.+a_{n-1}\,(Q_o+Q_1+\ldots.+Q_{n-2})]\,x$$
$$-\tfrac{1}{2}\,(Q_o+Q_1+\ldots.+Q_{n-1})\,x^2 \qquad (11)$$

A second integration for the inferior limit $x=o$, $y=y_{n-1}$ gives

$$E\,I\,(y-y_{n-1}-x\tan\beta_{n-1})=\tfrac{1}{4}\,(a_1+a_2+\ldots.+a_{n-1})^2\,x^2\,w+$$
$$\tfrac{1}{6}\,(a_1+a_2+\ldots.+a_{n-1})\,x^3\,w+\tfrac{1}{24}\,x^4\,w$$
$$-\tfrac{1}{2}\,[a_1\,Q_o+a_2\,(Q_o+Q_1)+a_3\,(Q_o+Q_1+Q_2)$$
$$+\ldots+a_{n-1}\,(Q_o+Q_1+\ldots+Q_{n-2})]\,x^2$$
$$-\tfrac{1}{6}\,(Q_o+Q_1+\ldots.+Q_{n-1})\,x^3 \qquad (12)$$

This is the equation of the elastic line between the points A_{n-1} and A_n. Substituting in equations (11) and (12) $x=a_n$ $y=y_n$ $\frac{d\,y}{d\,x}=\tan\beta_n$, there results

$$E\,I\,(\tan\beta_n-\tan\beta_{n-1})=\tfrac{1}{2}\,(a_1+a_2+\ldots.+a_{n-1})^2\,a_n\,w+\tfrac{1}{2}\,(a_1+a_2+\ldots+$$
$$a_{n-1})\,a_n^2\,w+\tfrac{1}{6}\,a_n^3\,w-[a_1\,Q_o+a_2\,(Q_o+Q_1)+a_3\,(Q_o+$$
$$Q_1+Q_2)+\ldots.+a_{n-1}\,(Q_o+Q_1+\ldots.+Q_{n-2})]\,a_n-$$
$$\tfrac{1}{2}\,(Q_1+Q_1+\ldots.+Q_{n-1})\,a_n^2 \qquad (13)$$

$$E\,I\left(\frac{y_n-y_{n-1}}{a_n}-\tan\beta_{n-1}\right)=\tfrac{1}{4}\,(a_1+a_2+\ldots.+a_{n-1})^2\,a_n\,w+\tfrac{1}{6}\,(a_1+a_2+\ldots$$
$$+a_{n-1})\,a_n^2\,w+\tfrac{1}{24}\,a_n^3\,w-\tfrac{1}{2}\,[a_1\,Q_o+a_2\,(Q_o+Q_1)$$
$$+a_3\,(Q_o+Q_1+Q_2)+\ldots.+a_{n-1}\,(Q_o+Q_o+Q_2+$$
$$\ldots.+Q_{n-2})]\,a_n-\tfrac{1}{6}\,(Q_o+Q_1+\ldots.+Q_{n1})\,a_n^2 \qquad (14)$$

These two equations, which are true for all indices $n=1=2=3$, &c., suffice, in connection with the two following general conditions of equilibrium of the entire system.

$$Q_o+Q_1+Q_2+\ldots\ldots=(a_1+a_2+a_3+\ldots\ldots)\,w \qquad (15)$$

$$a_1\,Q_o+a_2\,(Q_o+Q_1)+a_3\,(Q_o+Q_1+Q_2)+\ldots.=\tfrac{1}{2}\,(a_1+a_2+a_3+\ldots.)^2\,w \qquad (16)$$

to determine all unknown quantities involved in the problem. Ordinarily the values of y_n are given and Q_n and β_n required, as in the case of a beam uniformly loaded and supported at the points A_o A_1, &c. It may, however, occur, in certain points, that the force Q_n is given and y_n β_n required, as when Q_n is an isolated weight.

Subtracting eq. (14) from (13) there results

$$-E\,I\left(\frac{y_n-y_{n-1}}{a_n}-\tan\beta_n\right)=\tfrac{1}{2}\,(a_1+a_2+\ldots\ldots+a_{n-1})^2\,a_n\,w+\tfrac{1}{2}\,(a_1+a_2+\ldots\ldots a_{n-1})\,a_n^2\,w+\tfrac{1}{3}\,a_n^3\,w-\tfrac{1}{2}\,[a_1\,Q_0+a_2\,(Q_0+Q_1)+\ldots\ldots+a_{n-1}\,(Q_0+Q_1+\ldots\ldots+Q_{n-2})]\,a_n-\tfrac{1}{2}\,a_n^2\,(Q_0+Q_1+\ldots\ldots+Q_{n-1}) \quad (17)$$

And, changing the index in equation (14) from n to n + 1

$$E\,I\left(\frac{y_{n+1}-y_n}{a_{n+1}}-\tan\beta_n\right)=\tfrac{1}{2}\,(a_1+a_2+\ldots\ldots+a_n)^2\,a_{n+1}\,w+\tfrac{1}{6}\,(a_1+a_2+\ldots\ldots+a_n)\,a^2{}_{n+1}\,w+\tfrac{1}{3}\,a^3{}_{n+1}\,w-\tfrac{1}{2}\,[a_1\,Q_0+a_2\,(Q_0+Q_1)+a_3\,(Q_0+Q_1+Q_2)+\ldots\ldots+a_n\,(Q_0+Q_1+\ldots\ldots+Q_{n-1})]\,a_{n+1}-\tfrac{1}{6}\,a^2{}_{n+1}\,(Q_0+Q_1+\ldots\ldots+Q_n) \quad (18)$$

Adding these two equations and transposing the terms involving Q_n there results

$$\tfrac{1}{6}\,a^2{}_{n+1}\,(Q_0+Q_1+Q_2+\ldots\ldots+Q_n)=-E\,I\left(\frac{y_{n+1}-y_n}{a_{n+1}}-\frac{y_n-y_{n-1}}{a_n}\right)+\frac{a_n\,w}{24}\,[6\,(a_1+a_2+\ldots\ldots+a_{n-1})^2+8\,(a_1+a_2+\ldots\ldots+a_{n-1})\,a_n+3a^2{}_n]+\frac{a_{n+1}\,w}{24}\,[6\,(a_1+a_2+\ldots\ldots+a_n)^2+4\,(a_1+a_2+\ldots\ldots+a_n)\,a_{n+1}+a^2{}_{n+1}]-\tfrac{1}{2}\,(a_n+a_{n+1})\,[a_1\,Q_0+a_2\,(Q_0+Q_1)+\ldots\ldots+a_{n-1}\,(Q_0+Q_1+\ldots\ldots+Q_{n-2})]-\tfrac{1}{6}\,a_n\,(2\,a_n+3\,a_{n+1})\,(Q_0+Q_1+\ldots\ldots+Q_{n-1}) \quad (19)$$

(To be continued.)

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 31.)

"*System pursued in transmitting power from motors to the manufactory.*—In the location of mills on water-courses, it has commonly been deemed necessary to place the main building directly over the spots where the wheel-pits are unavoidably located, on some steep hill-side, or rocky precipice, however unfavorable the site may be for grading and for costly foundations, with dark and damp basement-rooms, unsuitable for occupancy by workmen.

"One of the most important advantages derivable from the new

system of transmitting power economically to a distance from water-wheels as motors, is practically available in selecting a good level site for the location of a manufactory.

"In carrying out this system at Georgiaville, the power has been transmitted several hundred feet from a bluff, where a fall of water of 36 feet descent was available by two successive falls of 20 and 16 feet each. To accomplish this task with the massive shafts and couplings then in common use (1852) appeared to be too costly, and difficult of execution with satisfactory results.

"Encouraged by previous experiments for practically transmitting power by swiftly revolving shafts and belts, the attempt was boldly made to carry the power to the manufactory, instead of carrying the manufactory to the power; which was necessarily located on a hill-side, where the wheel-pits were to be excavated.

"The motors were a pair of water-wheels, 24 feet diameter and 18 feet long, with a fall of water 20 feet, and a second pair of water-wheels, fifty yards above them, 18 feet diameter and 19 feet long, under a fall of 16 feet.

"A small shaft, only three inches diameter, if revolving with 200 revolutions per minnte, was deemed sufficient to transmit all the power of the upper pair of wheels; and by transmitting this power to another lower line of shafting of the same size, but with the velocity doubled to 400 revolutions per minute, it was also deemed sufficient to receive the additional power of one of the lower pair of 24 feet wheels. A driving-pulley of 10 feet diameter on the upper line of shafting, transmitted the power by a belt 12 inches wide to a five feet pulley on the lower shaft, to its double speed.

"This idea was more readily conceived than executed. The movement of a pulley of the dimensions of 10 feet diameter, with a surface velocity of over 6,000 feet per minute, had never before been attempted practically. Doubts were suggested of the safety of using belts with this velocity in mills. But after having trusted my own body to travel with the speed of a mile a minute, over English railways, with numerous other passengers, drawn by a ponderous locomotive engine of 35 tons weight, whirled around curves, over precipitous embankments, and uncertainly fastened rails, it seemed very rational to trust a leather belt to travel with the same speed. Thus reassured, the doubter might smile at the suggestion of danger of risking a light belt to journey at the same rate. But there had been no light pulleys made suitable for this use. Those previously in use, made of

two iron rims, covered with wooden lags bolted thereto, were rejected as unfit.

"Although the superior convenience of belts over wheel-work and shafting for transmitting power, had induced many attempts to use them thirty years ago, yet the experimenters had commonly failed of successfully operating them with the low rate of speed then used. Pulleys had not been made sufficiently light and well balanced for any one to adventure to use them with the high speed required for leather belts to operate advantageously. With the slow speed, it was necessary to strain the belts so tightly on the pulleys, to produce sufficient adhesion, without slipping around on the smooth surfaces, that the lacings and texture of the leather yielded; and so frequent repairs were required, that the superintendents of mills nearly all abandoned the use of them for transmitting the power from the motors to the mill shafting. They fell back on the old system of slowly revolving heavy shafting and wheels.

"To carry out the proposed system, new patterns of pulleys were therefore made. The first pulley, 10 feet diameter, proved to be imperfect, and when tested with a velocity of about 8,500 feet per minute, the rim soon made its exit through the roof of the wheel-house, and continued its course in a parabolic curve through the air several hundred yards, until it finally transmitted its motive power to plough a furrow in a meadow. A re-modelled pulley, made to take the place of the wandering one, stood the test, and has continued faithful, without deserting its post, to perform the duty assigned to it ever since, during a period of sixteen years. The same belt has also remained in use, in good order, after travelling about a quarter of a million of miles every year in its daily circuits, with a velocity of 6,000 feet per minute.

"As a test of the efficacy of this small three-inch shaft to transmit the power from three water-wheels, it may be stated that not a single shaft or coupling has required renewal or repairs, and they appear still capable of a much longer service. This same three-inch shaft has also served to transmit all the power of the steam engine used in times of drought.

"The contrast between the two systems of high and low rates of speed of shafts and belts, for transmitting power from motors to manufactories, is instructively exhibited in these two narrated instances of the practical application of each of them, with conclusive results of the failure of the latter.

"To avoid the use of the brittle teeth of wheels, quite recently the adhesion by friction of the surfaces of wheels has been employed for the transmission of power. To intensify the friction, the adhesion has been increased by turning grooves and ridges on the faces of the wheels brought together by pressure.

"This arrangement has been found advantageous for engaging and disengaging heavy washing machines and other apparatus in dye-houses and bleacheries, where leather and India rubber belts fail.

"It may be questioned whether there is not a great loss of power by transmission through a length of three hundred feet of a three-inch shafting?

"Undoubtedly some power is lost by friction in this case, but not so much as by the massy shafts described, or by a similar line of main shaftings in mills, where the friction is much augmented by loading the shafts with numerous pulleys, and by the tension of numerous belts.

"If kept in line and properly attended, the friction of a naked shaft of the length of three hundred feet is so small as to be easily turned by the hand of a man. The friction being caused by the weight of the shaft only, is not affected by any extent of power transmitted by it while revolving, whether it vary from one to an hundred horse-power.

"Where high velocities of mill gearing are used, it is desirable to limit any accidental extreme acceleration, that might prove injurious.

"This was readily accomplished by the simple arrangement of a latch to be lifted by a touch of the whirling arm of the ball regulator, whenever the accelerated speed causes it to rise to a certain prescribed limit. The lifting of this latch disengages the connection of the regulator with the gate of the water-wheel, and simultaneously engages another adjacent revolving wheel, that instantaneously shuts the gate more quickly than can be done by hand. By this automatic action the water-wheel itself is made a self-regulating machine.

"A wire extended from the distant mill, like a bell-wire, serves to communicate with the same latch by a slight pull of the hand, and to shut the gate of the water-wheel by the same automatic arrangement. This was devised for use only in case of accident, requiring the immediate stoppage of the machinery.

"This same system should be applied to automatically shutting off steam from an engine, whenever the velocity may accidentally be-

come accelerated beyond a prescribed limit, to endanger the machinery.

"The very important advantage of combining together the action of the several motors of a manufactory to coöperate in concert for equalizing the regulation of the speed of the looms, self-actors and other machines, requiring great uniformity of movements, is really available, where the velocity of a mile per minute of a connecting belt is adopted. While the strongest shafting and cog-wheels fail to accomplish this work, even with the most massive materials, as has been described, all four of the water-wheels of the Georgia Mill have been very satisfactorily and successfully made to act in unison by a single belt of only 8 inches in width. This belt serves to transmit back and forth between the motors any excess of power that either may receive, and to return any surplus, to an extent of sixty horse power. A range of variation of 120 horse power is thereby available for maintaining an equable movement of all the machines of a large manufactory, with admirable regularity. The elasticity and slight slipping of the belts relieves the shocks of more than one hundred tons of water-wheels, which break the teeth and shafting made of rigid, unyielding iron.

"This system was necessarily introduced to prevent the waste of water that ensues when two mill regulators are used to control the flow of water successively from one pair of wheels above another lower pair. The two regulators cannot be made to act harmoniously; for each one is governed by the varying load of machinery imposed on each motor. The annoying waste of the surplus water in times of drought, shut off by the regulators, and flowing past without useful effect, can be prevented entirely by using only one regulator on the upper wheels for controlling the whole of the machinery.

"Thus a small leather belt, of only eight inches width, has been successfully employed for many years, and is still employed, with the velocity of a mile a minute, to control the speed of four water-wheels, like leather reins to bridle four steeds.

"In a manufactory operated by two independent motors, with distinct lines of shafting, the two systems may be connected even by an inch belt moving with high velocity, to modify, wonderfully, the sudden extremes of speed,—so disadvantageous where machines are operated, requiring nice adjustments of power."—*From Proceedings of N. E. Cotton Manufacturer's Association, No.* 10, *April* 19, 1871.

EXPERIMENTS ON VARIOUS COALS OF THE CARBONIFEROUS AND CRETACEOUS PERIODS,

To Ascertain their Relative Potential and Economic Vaporizations. Made by Chief Engineer B. F. Isherwood, *U. S. Navy, at the Mare Island Navy Yard, California, in* 1871.

(Continued from page 122.)

Chemical composition of the coals.—The specific gravity, the hygrometric moisture, the ash and the clinker, in the coals experimented on, were determined in each case by the experimenter. The hygrometric moisture was ascertained by taking a large quantity of the coal, accurately weighing it, then reducing it to the finest powder, and finally exposing it for a considerable time to the temperature of 230 degrees Fahrenheit in a brine-bath, weighing it again immediately on taking it out. The vessel containing it was closely covered, and fitted with a small tube open at its outer end, which extended beyond the influence of the steam from the bath. The actual burning of the coal in the course of the experiment, of course, gave its ash and clinker. The remaining constituents of the coal, namely, its carbon, hydrogen, oxygen, nitrogen, and sulphur, are the average of all the analyses which had been made from time to time by various persons and for different purposes that the experimenter could collect. They amounted to several for each coal.

The following table exhibits the chemical composition of the different coals in units of weight, *exclusive* of their hygrometric moisture, ash and clinker:

Kind of coal.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Sulphur.
Anthracite of Pennsylvania Anthracite of Queen Charlotte Island	93·5	3·0	2·0	1·0	0·5
Welsh anthracitic	91·5	4·0	2·5	1·0	1·0
Semi-bituminous coal of Maryland	89·5	5·0	3·0	1·2	1·3
Australian brown coal (first sample)	84·11	5·43	8·49	1·26	0·71
Australian brown coal (second sample)	80·31	5·19	12·50	1·25	0·75
Rocky Mountain brown coal Mount Diablo brown coal Coose Bay brown coal Seattle brown coal	71·6	5·5	19·5	1·3	2·2
Bellingham Bay brown coal Nanaimo brown coal	77·5	5·3	14·0	1·3	1·9

The following table exhibits the chemical composition of the different coals in units of weight, *exclusive* of their hygrometric moisture, ash and clinker:

Kind of coal.	Specific gravity.	Ash and clinker.	Hygrometric moisture.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Sulphur.
Anthracite of Pennsylvania	1·453	14·84	1·16	78·54	2·32	1·68	0·84	0·42
Anthracite of Queen Charlotte Island	1·508	39·75	0·85	55·54	1·78	1·19	0·59	0·30
Welsh anthracitic	1·390	6.73	1·27	84·18	3·68	2.30	0.92	0·92
Semi-bituminous coal of Maryland	1·332	8·25	1·75	80·55	4·50	2·70	1·08	1·17
Australian brown coal (first sample)	1·275	8 07	3·93	74·02	4·78	7·47	1·11	0·62
Australian brown coal (second sample)	1·275	10·00	10·00	64·25	4·15	10·00	1·00	0·60
Rocky Mountain brown coal Mount Diablo brown coal Coose Bay brown coal Seattle brown coal	1·320	13·18	16·82	50·05	3·85	13·65	0·91	1·54
Bellingham Bay brown coal	1·350	23·48	12·52	49·00	3·39	8·96	0·83	1·22
Nanaimo brown coal	1·302	12·74	10·20	59·68	4·08	10·78	1·00	1·46
Coke from Nanaimo brown coal	0·868	13.85	13·00	.....	.....	.....	.....	.....

The following table exhibits the physical properties of the different coals, and of their earthy refuse:

Name of coal.	Weight of a cubic foot of coal in the merchantable state, in pounds.	Number of cubic feet of space required to stow one ton of coal.	Fraction of the space required to stow one ton of coal, occupied by solid matter.	Per centum of the earthy matter in the coal, of ash.	Per centum of the earthy matter in the coal, in clinker.	Specific gravity of the clinker.	Weight of a cubic foot of ash.	Weight of a cubic foot of clinker.
Anthracite of Pennsylvania	58·82	38·08	0·6489	70·00	30·00	1·331	56·47	40·00
Anthracite of Queen Charlotte Island	64·70	34·62	0·6877	63.53	36·47	2·062	51·41	46·35
Welsh anthracitic	56·85	39·40	0·6555	85·16	14 84	.....	34·60	.....
Semi-bituminous coal of Maryland	55·65	40·25	0·6697	85·16	14·84	1·820	32·00	38·85
Australian brown coal (first sample)	54·12	41·39	0·6804	64·22	35·78	1·852	34·50	40·24
Australian brown coal (second sample) Rocky Mountain brown coal Mount Diablo brown coal Coose Bay brown coal Seattle brown coal	53·36	41·98	0·6479	69·18	30·82	1·774	39·41	37·73
Bellingham Bay brown coal	60·70	46·00	0·7207	72·35	27·65	1·794	39·00	32·00
Nanaimo brown coal	51·77	43·27	0·6373	59·54	40·46	*2·362	*48·71	*47·65
Coke from Nanaimo coal	28·00	80·00	0·5170	47·79	52·21	2.488	44·47	48·70

* Mean of the results from the maximum and medium rates of combustion.

Comparison of the theoretic and economic vaporizations of the coals experimented on.—In the second column of the following table will be found the theoretical economic vaporizations of one pound of what remains of the different coals experimented on after deducting the ash and clinker. That is to say, the number of pounds of water which one pound of the gasifiable portion of the coal will vaporize from the temperature of 212 degrees Fahrenheit under the pressure of 29·92 inches of mercury.

The calorific part of the coal is its carbon, hydrogen and sulphur; and the calculation of the theoretical economic vaporization has been made by employing for these elements the calorific values ascertained by Favre and Silbermann, namely, 14544 Fahrenheit units of heat for the carbon, 62032 Fahrenheit units of heat for the hydrogen, and 3996 Fahrenheit units of heat for the sulphur. In other words, assuming that the combustion in oxygen of each pound of these elements will raise the temperature of the above number of pounds of water at 39 degrees Fahrenheit, one degree Fahrenheit.

In determining the weight of hydrogen to be employed in the calculation, the experimental weight is taken less one-eighth of the experimental weight of the oxygen in the gasifiable part of the coal. Finally, there is deducted from the sum of the calorific effects of the above elements in the gasifiable part of the coal, the calorific equivalent, in the same units, of the vaporization of the hygrometric moisture in that part, and the remainder being divided by the latent heat of steam of the pressure of 29·92 inches of mercury, namely, 965·7 Fahrenheit units, the quotient is the theoretical economic vaporization in pounds of water from the temperature of 212 degrees Fahrenheit under the pressure of 29·92 inches of mercury, by one pound of the gasifiable part of the coal.

By the side of the quantities thus obtained, have been placed, in other columns, the experimental vaporizations by one pound of the gasifiable portion of the coal consumed at the maximum, the medium and the slow rate of combustion, under the same conditions of temperature and pressure; and, in an adjacent column to each, will be found the fractions which the experimental economic vaporizations are of the theoretical economic vaporizations.

Referring to the last column of the following table, the experimental economic vaporization given by the different coals except anthracite, is nearly the same fraction of their theoretical economic vaporization. Were these fractions exactly the same, then the relative experimental economic vaporization of these very diversely constituted coals could be calculated from their chemical composition. Probably such is the fact, in which case the discrepancies from equality in the last column of the table are due to other causes than want of truth in this law. Among these causes are the following:

1st. The chemical analysis made of a few grains of coal cannot be relied on to give the exact composition of the large mass from which they were selected; neither can the coal from different parts of the

Kind of coal.	Economic vaporizations in pounds of water from the temperature of 212° Fahrenheit under the pressure of 29·92 inches of mercury per pound of the gasifiable portion of the coal.						
		Experimental.					
	Theoretical.	At the maximum rate of combustion.	Fraction which the experimental is of the theoretical vaporization.	At the medium rate of combustion.	Fraction which the experimental is of the theoretical vaporization.	At the slow rate of combustion.	Fraction which the experimental is of the theoretical vaporization.
Anthracite of Pennsylvania	15·637	9·501	0·6078	9·472	0·6057	9·413	0·6020
Anthracite of Queen Charlotte Island	15·809	.....	.....	.....	.....	9·472	0·6068
Welsh anthracitic	15·952	9·851	0·6175	9·681	0·6069	10·673	0·6691
Semi bituminous coal of Maryland	16·165	9·896	0·6122	10·246	0·6338	10·557	0·6501
Australian brown coal (first sample)	14·844	8·560	0·5767	9·898	0·6668	9·664	0·6510
Australian brown coal (second sample)	12·720	7·966	0·6263	8·509	0·6689	8·930	0·7020
Rocky Mountain brown coal Mount Diablo brown coal Coose Bay brown coal Seattle brown coal	10·114	5·420	0·5359	6·062	0·5994	6·907	0·6829
Bellingham Bay brown coal	11·554	5·778	0·5005	6·912	0·5987	8·006	0·6935
Nanaimo brown coal	12·243	6·786	0·5544	8·432	0·6887	8·249	0·6738

same vein in the same mine be relied on as having the same chemical composition; the variation, perhaps, may not be great, yet a small difference in the hydrogen element will materially affect the result.

2d. Neither the hygrometric nor the barometric conditions of the air are the same in every experiment, nor can the firing be depended on as equal at all times, though done by the same man. If the grate be not kept equally well covered, the economic result will be affected in a very marked manner; and a difference in the cleanliness and thickness of the fires will also cause a difference.

3d. The area of heat-absorbing surfaces in the boiler is not sufficient to reduce the temperature of the gaseous products of combustion to the temperature of the water within the boiler, even with the smallest quantity of heat that was thrown upon them during any experiment. Now, although the vaporizations from which the fractions in the last column of the table were calculated are those given by the slow rate of combustion, and although this rate was nearly the same for all the coals, yet, as the calorific effect of one pound of the gasifiable portion of some of the coals greatly exceeded that of others—even to the extent of one-half more—very different quantities of heat were thrown in the same time on the same heat-absorbing surface, and, as a consequence, the temperature of the gaseous products of combustion could not be equally reduced. In this connection it is worthy of notice that the experimental economic vaporizations of the

poorer coals are the largest fractions of their theoretical economic vaporizations.

As the slow-burning anthracite has a larger air-supply in proportion to weight burned than the rapidly-burning brown coals, the furnace-temperature with it will be lower than with them, and, as a consequence, their experimental economic vaporizations, for equal temperatures of the gaseous products of combustion when leaving the boiler, being disproportionately reduced, will be less fractions of their theoretical economic vaporizations.

In the experiments with the maximum rate of combustion, the quantity of heat thrown in equal times upon the heat-absorbing surfaces of the boiler did not vary so greatly as in the experiments with the slow rate of combustion; hence it might be supposed that the experimental economic evaporizations with the maximum rate of combustion would be more nearly the same fraction of the theoretical economic vaporizations than with the slow rate of combustion, provided the relative calorific values of the coals were calculable from their chemical composition. But this deduction must be greatly modified by the fact that the bulks, *ceteris paribus*, of the gaseous products of combustion of the different coals differed enormously when equal quantities of heat were developed in equal times, and that, under this condition, the times during which these products were in contact with the heat-absorbing surfaces are inversely proportional to those bulks. Now, as the heat-absorbing surfaces of the boiler were not of sufficient extent, in any case, to reduce the temperature of the gaseous products of combustion to that of the water within the boiler, in the time during which these products were in contact with the surfaces, the enormous difference in that time for the different coals when developing equal quanties of heat in equal times must have greatly affected the fraction which the experimental economic vaporization is of the theoretical economic vaporization. In support of this consideration, the poorer coals, that is those which have the greatest bulk of gaseous products of combustion in proportion to the contained heat, gave, at the maximum rate of combustion, a smaller fraction of the theoretical economic vaporization than at the slow rate of combustion.

Relative weights of steam obtainable from equal bulks of the coals experimented on.—For steam vessels, in which a given space is allotted to the coal carried, it is important to know the relative weights of steam obtainable from equal bulks of the coals experimented on; and as this relation varies for the different rates of combustion, it will be ascertained for the experimental maximum, medium and slow rates.

In determining this problem, the weight of the coals in pounds per cubic foot will be taken as the measure of their mass in equal bulks; and the number of pounds of water at the temperature of 212 degrees Fahrenheit vaporized under the pressure of 29·92 inches of mercury by one pound of the coals at the different rates of combustion (line 29, tables Nos. 1 and 2, modified for the average per centum of ash and clinker given by the coal for the entire quantity consumed, with all the rates of combustion), multiplied by the number of pounds of the coals in a cubic foot, will be taken as the measure of the weights of steam obtainable from equal bulks of the coals.

In the following table will be found the results of the computations for the different rates of combustion, expressed both absolutely and relatively; taking, in the latter case, those of the Pennsylvania anthracite for unity.

Kind of coal.	Weights of steam obtained from a cubic foot of the different coals consumed at the maximum, medium, and slow rates of combustion.					
	Maximum combustion.		Medium combustion.		Slow combustion.	
	Pounds	Relatively.	Pounds.	Relatively.	Pounds.	Relatively.
Anthracite of Pennsylvania	476·06	1·0000	474·46	1·0000	471·51	1·0000
Anthracite of Queen Charlotte Island	.....	.....	.....	.....	369·37	0·7834
Welsh anthracitic	522·34	1·0972	513·32	1·0819	565·92	1·2002
Semi-bituminous coal of Maryland	505·28	1·0614	533·15	1·1026	539·05	1·1432
Australian brown coal, 1st sample	425·84	0·8946	492·45	1·0379	480·81	1·0197
Australian brown coal, 2d sample	388·01	0·8150	414·46	0·8735	434·96	0·9225
Rocky Mountain brown coal	251·09	0·5274	280·83	0·5919	319·98	0·6786
Mount Diablo Brown coal						
Coose Bay brown coal						
Seattle brown coal						
Bellingham Bay brown coal	268·37	0·5637	321·05	0·6766	371·86	0·7886
Nanaimo brown coal	306·04	0·6441	380·91	0·8028	372·64	0·7903
Coke from the Nanaimo coal	192·09	0·4048	186·10	0·3922	192·47	0·4082

Effect of the earthy portion of the coal on the economic vaporization of its gasifiable portion.—Whether the earthy matter of the coal was a greater or less per centum of it, seems not to sensibly affect the economic vaporization of the gasifiable portion; for the economic vaporization of the gasifiable portion of the Queen Charlotte Island anthracite was almost identical with that of the Pennsylvania anthracite, the chemical composition of both anthracites being the same, excepting the per centum of earthy matter, which was 14·84 in the latter and 39·75 in the former; a difference so great that any effect due this cause ought to have been strongly marked.

Chemistry, Physics, Technology, etc.

ON THE NATURE OF WHITE LIGHT.

By Prof. Edwin J. Houston,
Of the Central High School of Philadelphia.

Though familiarized with the marvellous possibilities of ordinary sunlight by their constant recurrence, we need but little reflection to apprehend their exceeding complexity. In the sunlight, the infinite variety of the tints of nature are ever present: we note the sombres gray and browns of her rocky bluffs, the azure tints of her firmament, the rich hues of her vegetable and animal life, and the glories of her clouds and billows, with their ever-changing phases; the sunlight gone, nothing remains but form, shape, figure.

The difficulty of obtaining a clear insight into the nature of this wonderful agent is real, and can hardly be over-estimated. Accepting the undulatory theory, we must believe that each of the colored rays emitted from different objects, is produced by a definite rate of vibration of the luminiferous ether, and is to be distinguished from other colored rays by variations in the amplitude and wave length of the oscillations.

And here a question presents itself which, in one form or another, is constantly recurring. Does the light contain all these colored rays before it falls on objects, or do they arise from an action of the objects themselves on the light? We hold light to arise from a vibration of ether. Does uncolored sunlight result from a single, simple vibration, a compound mean vibration, or from the actual presence of an almost infinite variety of separate vibrations? When a spectrum is formed by a prism, were all the colored rays actually present before incidence, or were they evolved by the prism's dispersive power? We know that musical tones are never pure, but always associated with overtones, which coëxist with the fundamental. Is there any analogy in the case of white light? Is it produced by a single mean vibration, unassociated with others, or by waves that have countless smaller waves superimposed on them? Should we regard the production of a spectrum as a real decomposition, or only as a further separation of rays already distinct?

It must be confessed that, in the present state of our science, many of these questions are difficult, if not impossible, of solution.

It would appear from an examination of the writings of Newton, that one of the principal reasons that led him to reject any pure undulatory theory of light, and to propose his mixed, undulatory and corpuscular hypothesis, was the difficulty of conceiving how, on mechanical principles, so many motions could cöexist without interference, or how, were a mean motion produced by the combination of many separate motions, it could afterwards, without receiving unequal impulses, be decomposed, or resolved into exactly those motions of which it was originally compounded. Answering an objector to his theory, who held a pure, undulatory hypothesis, he says,* "He must first shew that many unlike motions in a Fluid can, by clashing, so act on one another, and change one another, as to become an uniform Motion; and then, that an uniform Motion can of itself, without any new unequal Impressions, depart into a great Variety of Motions regularly unequal."

It is purposed, in this paper, to consider the three following apparently consistent views, that may be taken concerning the nature of the composition or constitution of a so-called ray of ordinary sunlight:

1st. That white light is produced by a single, simple wave, possessing a definite rate of vibration and wave length, which, on its dispersion by a prism, or on its incidence on a colored object, is so shivered or shattered as to originate an almost infinite variety of waves of different refrangibilities.

2d. That white light is produced by a compound wave, which is a resultant of all the prismatic rays. That these prismatic rays, or components, do not possess any separate individuality, but are merged with, and lost in, that of the resultant.

3d. That white light is produced neither by a simple vibration, nor a compound resultant vibration, but by an almost infinite number of separate, single and simple vibrations, which, under ordinary circumstances, are so related to each other by position, number and intensity, as to produce in the eye the effect of white light. That on passing through a prism, so as to suffer dispersion, or on being emitted from a colored body, their position, number and relative intensity are so altered as to enable them to assert their individuality, either as new groups of rays, or as separate, single rays.

I shall endeavor, briefly, to point out some of the objections to

* Phil. Trans. 1672.

which all of these views are open, and to show in what respect the last appears to be the least objectionable.

1st. That white light is produced by a single, simple ray, possessing a definite wave length.

Apart from the lower heat rays that accompany uncolored sunlight, the vast number of secondary or derivative waves, which we must conceive it to originate, by simply passing through a substance possessing dispersive powers, or falling on a colored body, renders the supposition of its simple nature highly improbable. Moreover, when we consider that each of this vast multitude of rays possesses a distinct individuality, has a definite wave length, a peculiar index of refraction, and characteristic luminous, thermal or actinic powers, the improbability of the production of all these from a single wave, becomes more and more apparent. This conception of the nature of white light has so little to recommend it, that I shall give it no further consideration.

2d. That white light is produced by a compound vibration, which is the resultant of all the prismatic rays.

Like the simple, single wave of the first supposition, this compound wave must possess a definite rate of vibration and wave length. The two suppositions, however, differ in this respect, that while the first considers the light produced by a wave that is inherently a simple one, the other considers it as produced by one that is simple only in virtue of a certain definite equilibrium, existing among its components; and that while we can see no way in which a single wave could generate such a vast number of others, all differing among themselves, we can readily understand that any disturbance in the equilibrium existing among the components of the compound wave, must necessitate either the production of one or more new compound waves, arising from a redistribution of the forces under new conditions of equilibrium, or a complete separation of the wave into all its component parts.

A casual consideration of the difficulty of explaining the ordinary phenomena of light, on the assumption of the actual presence of all the rays, might induce us to accept the supposition of a compound wave as the least objectionable, were it not for the following grave objections, which appear to render its adoption impossible:

If the prismatic tints do not exist in white light as separate waves, but as components, then the resultant must be a mean, of some kind, of these components. Out of the multitude of waves of varying

lengths, there must result one whose length is the average length of the whole, and this resultant wave must, of course, have a definite rate of vibration and wave length. If the components be limited to the prismatic waves between the red and the violet, the mean will fall somewhere in the visible spectrum, perhaps, near the green. Now as an incandescent solid heated to whiteness, is assumed to give off light of all degrees of refrangibility between the red and the violet, it should emit a ray of white light at that point of the spectrum, where the wave length and refrangibility coincide with the average wave length of all the rays, and, moreover, this ray of white light should be clearly discerned in the spectrum. Again, when the violet tints are reached, and the body has emitted its last needed component, all combine and white light again appears, differing in no respect from that which already should have been seen in the spectrum, save only in its greater intensity. The fact that white light has never been seen in the spectrum between the red and the violet, necessitates the rejection of the hypothesis. It may be urged against these objections, that we should not limit the component rays to the visible spectrum, but should include the invisible rays beyond the violet; though a valid objection, it does not remove the difficulty, for the mean ray, even then, could hardly be conceived as falling outside the limits of the visible spectrum, and when once located, the same objections hold good.

A further necessary application of the theory of a resultant wave introduces new difficulties. Grant that white light has a definite wave length and refrangibility. Now it has been shown that not only can white light be produced by the combination of all the prismatic colors, but also by the combination or mingling of any color with its complementary. And so we would have one white light resulting as a mean, from the mixture of red and green, another from that of violet and yellow, another from orange and blue, and so for all the intermediate colors and their complementaries. These resultants, if they are to be so considered, must necessarily differ in their wave lengths, and so *we would be forced to the conclusion that there are different kinds of white light.*

Should it be doubted, as has been done, whether two monochromatic colors are sufficient in themselves to produce white light, it cannot be denied that white light has been produced by the commingling of much less than all the colors of the spectrum, and that too of those portions, whose average wave length is less than that of the whole.

It is true that colored lights when mingled produce an intermediate resultant tint, whose wave length is approximately, if not absolutely, the mean of the two. Thus, yellow and red, when mingled, produce orange, and so for the other intermediate tints; but so, on the other hand, white light is produced by the mingling of all the prismatic tints. *These effects, however, are not produced outside of us by any averaging of wave lengths, but within us by an averaging of sensations, imparted by separate waves, to the delicate expansions of the optic nerve.*

3d. That in white light all the rays are not merely potentially, but actually present.

The careful study of spectra in spectrum analysis, has shown that the number of waves into which white light is analysed by the dispersion of a prism is exceedingly great, indeed almost incredible.

The dark lines of Fraunhofer, observable in the solar spectrum, mark places where waves of certain refrangibilities are missing. Over three thousand of these have been carefully mapped, and their wave lengths determined. They comprise comparatively but a small portion of the spectrum, so small indeed that ordinarily they are not discernible, unless the prisms employed have considerable dispersive power and the image of the spectrum is magnified by a lens. If, therefore, within these inappreciable portions of the spectrum the positions of so great a number of definite waves has been noticed, the number existing within the extreme limits of the spectrum, including the thermal and actinic rays, must be nearly infinite.

To hold, therefore, that all of these rays are not merely potentially, but actually, present in white light, as separately and characteristically distinct waves, is to urge a theory of white light which although it may be rejected from its very complexity, still, appears to be the only one of the three at all tenable.

As the mere fact of the presence of the dark lines of Fraunhofer in every solar spectrum, offers an argument against any theory of a resultant wave that can be framed, since no satisfactory reason can be adduced to show how a mean resultant wave could be so compounded that it would, on its decomposition, separate into an almost infinite number of different waves of regularly decreasing wave lengths, with no less than three thousand definite places, where waves, though not absolutely missing, at least are of such feeble intensity that their light appears dark by contrast with that of the main body of the spectrum.

I deem this an unanswerable objection to the second hypothesis of the nature of white or uncolored sun light.

An examination of other phenomena of light will further show the difficulty of holding any resultant theory.

In the interference phenomena observed in thin plates, the presence of the bands of color cannot be explained, except on the assumption that the interfering light is composed of innumerable rays of different wave-lengths. The assumption of a single resultant wave would only be adequate to account for bands of light of one color, shading insensibly into dark bands.

In order to show more fully the impossibility of explaining these and similar phenomena, without regarding all the rays as present in an uncombined state, brief reference will be made to the conditions of some of these familiar phenomena.

Let A B C represent a film of any transparent substance, as, for instance, that of a soap bubble. A portion of the light incident at B is reflected in the direction B C; the remainder, which constitutes by far the greater part, is refracted to E, where it is again divided, the greater portion emerging in the direction E F, and what remains passing by reflection to I, where another separation occurs, a part taking the direction I D, and the other I H, emerging at H G. Either of the two rays, B C and I D, or E F and H G, are in a condition to interfere with each other; for, in each set, one has been retarded behind its neighbor, by having passed through a distance greater than it, by about twice the thickness of the film.

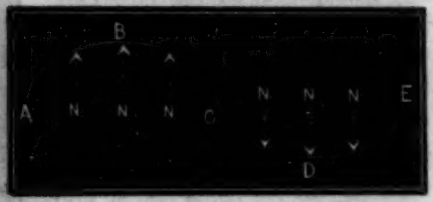
Now, if we consider that each of these rays is produced by a single compound vibration, and that their wave lengths are equal, the only effect that interference can produce in them, is a variation in their amplitude or intensity, and therefore, there should occur alternate dark and bright bands of the same color as the interfering light. *But in no case could bands of different colors be produced, since they are caused by varying wave lengths, and no variation in the wave lengths has occurred.*

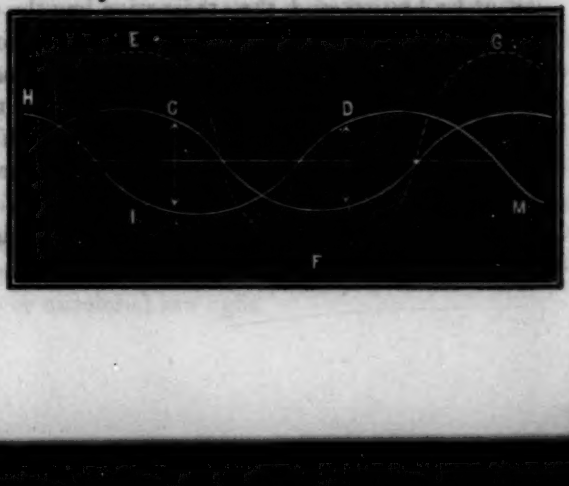
Let us endeavor to clearly apprehend the truth of this statement.

Let C D E F G represent the wave motion of the supposed resultant ray of light, or that of any single ray of colored light.

Interference will occur whenever another wave meets it in an opposite phase; but what we will endeavor to show is, that no matter how the two interfering waves may differ in their intensities, provided their wave lengths are the same before interference, they will remain equal after interference, no matter what the variation of the phases in which they meet. Their intensities, however, that is, the amplitude of their oscillations, may vary from nothing to the sum of the two.

Let A B C D E be a single wave propagated in the direction A E, then the vibrations of particles of luminiferous ether along this line will take place at right angles to this direction, that is, in the direction of the arrows N N N, N N N, the motion in the phase of elevation, A B C, being upwards, that in the phase of depression, C D E, downwards. Now, let a second wave, A F G E, of equal length, meet A B C D E in exactly opposite phases. It is clear that the vibratory motion will be entirely checked, since the upward and downward motions, as shown by the arrows, exactly neutralize each other. Suppose they meet in any other position, as in the figure, it is clear that nodes will be produced wherever the upward and downward motions are equal, that is at C and D, and from





the simple properties of the curves, as may also be found by superposition, it is evident that the distance between these points, which is half a wave length, is exactly one-half a wave length of the original light, or, in other words, that the resultant wave is of the same length as either of the interfering waves.

In the case we have supposed, the amplitudes of the waves are the same; but it will be seen by an inspection of the last figure, that the wave lengths will be the same whatever the amplitudes. Thus let the dotted line, E F G, in the last figure, represent a wave of greater amplitude than H I D M, but equal to it in wave length, then the node will fall to the right of C, and since the phases of elevation and depression are in each wave symmetrical curves, the second node must fall an equal distance to the right of D, and the wave length remain the same.

It is well-known as an experimental fact, that when monochromatic light is employed to produce interference effects in thin films, the bands are in all cases alternately bright and dark, as we have shown they should be. *Now, since when sun light is employed, bands of all the prismatic colors are produced, we must conclude that the interfering light cannot be of one common wave length, but must contain as many separate and distinct waves as there are tints in the prismatic bands.*

Should it be objected, that in the passage of the rays through the film they have suffered dispersion, and therefore are composed of rays of many wave lengths, we may remove the objection by citing a case of the production of colored bands by interference, under circumstances where dispersion is impossible.

A luminous point is placed before two plain mirrors, inclined to each other at a very obtuse angle. The light which is reflected from the mirrors is in a condition to interfere, and *colored bands are produced.* Now, here there was no refraction, and hence no dispersion.

But, it may be asked, is the explanation any clearer on the assumption that white or uncolored light contains all the different rays as separate and definite waves? It will be noticed that the explanation generally given of these interference phenomena, tacitly assumes the presence of all the rays as entirely separate and distinct from each other. We have seen that when homogeneous colored light is employed to produce the interferences, there result alternate bright and dark bands, of the same color as the interfering light, so that just at that point of the film where twice its thickness equals a wave length

of red light, or any even number of times its wave length, those rays of red light, which are present in the white light, interfere and produce bright bands of red; where twice the thickness of the film equals one-half, or any odd number of times a wave length, the interference is total and darkness results; for intermediate points it varies, hence the red bands shade insensibly into the dark ones, and so for each of the other colors. The dark bands are, however, not necessarily visible, since their place may be occupied by the bright ones of the succeeding color.

It will be noticed that, in these explanations, in speaking of the interference of waves meeting in the same phase as producing an increased light, I have stated the facts as they should be according to the undulatory theory. In truth, however, in all or nearly all instances in which waves interfere after they have travelled over the same distances—except when the light has undergone an anatropy, or inversion of properties—*the bands are invariably dark.*

An objection of a similar character is offered by the interference colors produced by the diffraction of light.

If a distant luminous point, as a candle, be looked at through a narrow slit in a card, and a thin hair be held parallel to the slit, and between it and the luminous point, colored fringes will be observed on each side of the shadow of the hair. The breadth of the bands is greater as the diameter of the hair diminishes, while if the diameter becomes great they disappear altogether. Similar phenomena may be observed by holding a small lock of wool between the eye and the luminous point, which will be seen surrounded by colored rings of considerable breadth and intensity, if the filaments of the wool are very fine and nearly of the same size. A fine feather can be employed instead of the lock of wool. The haloes, or prismatic rings, seen around the sun and moon during certain conditions of the atmosphere, are caused, as Fraunhofer has shown, by the diffraction of the light, consequent on its passage through air loaded with small globules of water. Other diffraction effects occur in the colored fringes noticed under peculiar circumstances around the shadows of opaque bodies; in the diffraction spectra produced by "gratings;" in the iridescence of mother-of-pearl and many mineral substances, and in numerous other instances.

Now, in all these cases the colors result either from the interference of a ray which has just grazed the edge of the opaque body with one that has passed clear of that edge, or from that of two rays that have

been unequally inflected or bent into the geometrical shadow of the opaque body. From the unequal distances passed over by the two rays, one is retarded behind its neighbor some portion of its wave length, and produces interference effects in a manner similar to their production in thin plates. Now, in all these cases, *colored bands are produced*, whereas we have shown that if the interfering lights are supposed to possess the same wave lengths, as must be the case if they be resultant waves, the only possible effect would be the production of alternate bright and dark bands of a monochromatic tint. *Hence, we must infer here, as in the previous case, the actual presence of all the colored rays as distinct and separate waves.* The truth of these conclusions is further shown by the fact, that whenever monochromatic light is used to produce diffraction experiments, the resultant bands are, as we have conceived them, bright bands shading insensibly into dark ones.

If the view we have stated of the exceeding complex nature of white light be true, many of our conceptions of pencils, beams and rays will, perhaps, require some essential modifications. As this assumption of the constitution of white light necessarily requires the presence of all the prismatic rays, as separate and independent waves, it follows that a so-called ray, or single line of white light, is in reality a vast bundle of rays, very near each other, and *that a single ray, using the term as we do when applied to a single ray of colored light produced by one wave, has, outside of the eye, no real existence.*

The primary idea of polarity is that of different properties on different sides or at different ends, as, for instance, the attractive and repellant forces at the ends of a magnet. Even Newton, in his mixed Undulatory and Corpuscular Theory of Light, saw the necessity of giving his luminiferous corpuscles different properties on different sides, in order to account for the phenomena of double refraction.

Our present somewhat indefinite conception, in accordance with the undulatory theory, of the nature of polarized light, is only carrying out this idea further; since, on the assumption that the vibrations of each of the particles of the luminiferous ether generating the separate colored waves, all occur in planes parallel to each other, the light must necessarily have different properties, as the different sides of the beams are presented to the reflecting or refracting media.

Now, confining our idea of polarity to its original signification, it follows, from our conception of white light, that, unless we suppose

each so called ray to have a different arrangement of its individual colored rays, it is in reality polarized, since, being a bundle, it must possess different properties, according as it is presented *on its most or least refrangible side, that is, on the side containing a preponderance of rays of greater or less refrangibility.* The character of this polarization, however, would depend on the shape we conceive the bundle to possess; if square or rectangular, then we have polarization on two sides; if circular, polarization on all sides, and so for any intermediate polygonal form.

According to the undulatory theory, the vibrations of the luminiferous ether are conceived as taking place at right angles to the direction in which the light is moving. Assuming that each of the prismatic rays constituting a bundle, or optical ray of white light, to be produced by vibrations moving in a definite plane, each of the different rays moving in different planes at right angles to the direction in which the light is moving, then polarization, as ordinarily understood, would consist in bringing all these planes parallel to each other. On this assumption, we could have a single ray of white light, using the term ray provisionally, susceptible of polarization. But on no other assumption can we conceive of the polarization of a single ray of light.

As regards the exact nature of polarized white light, it must be confessed that our ideas are rather vague, but, like ordinary white light, it must contain all the prismatic rays as separate and independent waves. The proof is drawn from the well-known phenomena noticed in the interference of polarized light. When a beam of such light is caused to pass through a thin plate of some double refracting substance, and the transmitted light examined with an analyzer, beautiful interference colors are seen. The interference is produced as follows: the ordinary and the extraordinary rays, traversing the double refracting plate with different velocities, one is retarded behind the other by an amount dependent on the difference of these velocities and the thickness of the plate, and on emerging from the plate the two rays interfere with each other. These interference colors, however, cannot be seen in ordinary light; they must be looked at through an analyzer. By interference some of the colored rays are extinguished, while others are augmented; and it is to these augmented waves, that the wonderful brilliancy of the tints of polarization interference colors are due. As in all the interference effects before discussed, we must suppose the presence of all the colored rays, as separate entities.

Before we can obtain a clear conception of the marvellously complex nature of white sunlight, according to the hypothesis which we have at least shown to be probable, if not necessary, an additional consideration, at which we have already hinted, is necessary.

The sun's spectrum is not continuous. Certain waves are missing. Nor is the number of these missing waves inconsiderable. Thousands can be shown to exist, and doubtless others will be discovered as our means of detecting them become less imperfect. These lines, however, are not absolute gaps in the spectrum, but merely places where the intensity of the light is so much less than that from the rest of the spectrum, that they appear dark by contrast.

Solid bodies, when incandescent, yield continuous spectra, and so in reality does the sun; but the faintly luminous atmosphere of flaming or incandescent gas surrounding its main body, absorbs those rays that are of the same color as the light it itself emits. There is no absorption, however, of this feebly luminous light, and it accompanies the brighter sunlight; so that the sun's spectrum at the earth is really continuous, though optically it does not appear so.

A single line of light, which is the smallest quantity we can have, is called a ray. Now, it is clear that all the prismatic rays are necessary to produce the white light of the sun, and so a ray of this light must be composed of a vast number of bundles of colored rays, sharply separated by other bundles of feebler rays, whose refrangibilities correspond to the dark lines of Fraunhofer. The independent co-existence of all these colored rays is not only difficult to imagine on mechanical grounds, but may, perhaps, somewhat alter our conceptions of a ray of ordinary sunlight. *It must have thickness.* Since the vibrations of the luminiferous ether occur at right angles to the direction of the ray, each single ray must of necessity have one of its dimensions equal to the amplitude of the oscillations of its ether particles. Assign the smallest positive value to this amplitude, and, as the number of rays actually present in a single ray of sunlight is practically infinite, the thickness of one ray must be conceived sensible.

To that ever present species of polarization of common light, to which we have already alluded, and to the appreciable thickness which a ray must possess, may perhaps be ascribed the curious inversion of the properties of sunlight known as its anatropy, which is observable whenever it passes through a small aperture, or just grazes the edge of a thin plate.

The arguments in favor of the actual presence of all the rays in ordinary sunlight are of such a convincing nature, that it may appear impossible that any other theory could have reasonably been held. So far, however, as my reading has gone, I have failed to find anywhere any definite statement of the nature of the supposed composition of ordinary sunlight, and in an endeavor to determine that nature for myself, have been led to indulge in these speculations.

But yet, on the other hand, the idea of a ray of light, to which we are forced by the preceding conclusions, is so complicated as to almost baffle conception. Consider carefully what we must believe, if we hold this theory of the nature of ordinary sunlight. What is a so-called ray? A bundle containing an infinite number of rays, arranged in a multitude of smaller bundles, which, at points, the position of each of which is distinct and always the same, are sharply separated from each other by no less than three thousand places, where smaller bundles exist, containing the feebly luminous rays corresponding to Fraunhofer's dark lines. Bear in mind that each of these rays is assumed as distinct; as produced, not by the flight of a minute corpuscle, shot out in a straight line, but by an undulation or wave, that must occupy some sensible space by its breadth or thickness, as well as by its length. Bear in mind that each of these rays is absolutely a distinct entity, possessing characteristic thermal, luminous, or actinic powers, and this conception mastered, remember that the light which is emitted from different portions of the main body of the sun, and from different portions of his various gaseous envelopes, possess different properties, and that in every ray of light most, if not all, of these rays are actually present. Finally, remember that the countless waves from each of the stars that are in the firmament above us, and which are distinctly visible at night, are potentially if not actually present in the sunlight, being only obscured by its greater brilliancy.

Then what a marvellous amount of motion must be crowded into the space occupied by a single ray of light! The smallest portion of a white body, that is a body which gives off all the rays of light, that is visible to the naked eye, is quite minute; with the microscope, even this portion becomes wonderfully diminished, and yet, if it appears white, we must conceive this minute point as the genesis of an infinite number of rays. What a clashing of various motions must this place witness! And yet in this crowded space each wave speeds on, and, indifferent it might seem to the intricate maze of motion around it,

asserts its own individuality. Were we able to see a point so small as to be incapable of reflecting more than a part of these separate rays, it is clear that it could not appear white.

And if it be true that the minutest visible point is constantly throwing off such a vast multitude of waves, what must be the number thrown off from from all the visible points in a distant landscape. Isolate a single point. By the undulatory theory, it must send off waves in all directions through the surrounding ether; heat waves, light waves, actinic waves and, mayhaps, electric waves. Now introduce all the visible points, and remember that each of them does the same, and then let him conceive, who can, the immense work which is laid upon the assumed universal ether.

Should it be urged that the theorizing, in which we have indulged, has only led to much greater complexity in our ideas of ordinary sunlight, and to much greater difficulties in our explanations or conceptions of familiar phenomena, we would suggest that, although the aim of all science should be towards generalization and consequent simplicity of ideas, yet the deeper we penetrate into the mysteries of nature, the more are we lost in amazement at the wonderful character of her operations. In small things, as well as in great, the same marvel of possibilities meets us. Even in a familiar agent like common sunlight, we are well nigh baffled in our attempts at gaining a clear insight into the constitution of one of its rays, and yet, before it is possible to make real progress in the development of physical optics, such a conception is absolutely necessary.

CONCERNING CERTAIN DETAILS OF THE BESSEMER PROCESS.

To accompany the model of the Self-gauging Tuyere. Presented to the Franklin Institute July, 1872.

By C. H. Baker.

The refractory material composing the bottoms of Bessemer Converters is gradually worn away by exposure to successive "blows" from a number of causes, among which may be mentioned the quality and solidity of the "refractory" itself, the heat and impact of the charge, and the hurtful action of the blast of air by which decarburization is effected.

With this refractory material, the fire-brick "tuyeres," which admit the blast and pass entirely through the bottom, are correspondingly worn off and shortened. The molten iron is in actual contact with

the upper surface of both, and this erosion continues until the bottom is no longer fit for use.

In view of this fact, and since the number of charges a bottom will resist is variable, it is necessary, after the first two or three blows, to ascertain its change of level in order that an opinion may be formed as to how often it may be used with safety thereafter. This is effected by *measuring the tuyeres* by means of a wire run through their perforations; notice is also taken of the *appearance* of the bottom by looking upward into the inverted vessel, the surface of the bottom and perforations of the tuyeres being ordinarily plainly visible.

Fig. 1.

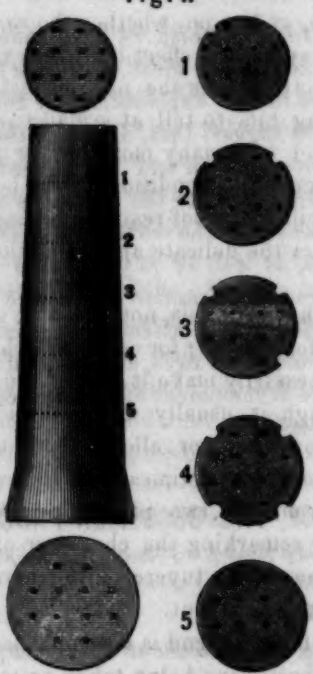
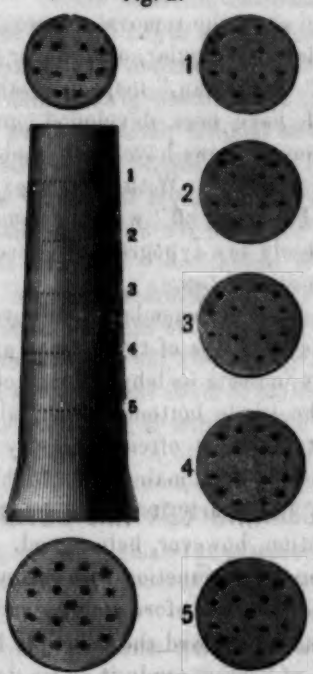


Fig. 2.



The self-gauging tuyere dispenses with the labor incident to measuring the tuyeres, saves the time thus occupied, and avoids the exposure to the heat of the vessel, &c., otherwise attendant on this duty. This is effected by simply introducing a number of "blind-holes," or perforations running but *partially through* the tuyere; these are made differing in length from each other by a certain constant distance,

which is also that by which the longest blind-hole differs in length from the regular perforations of the tuyere. To the shortest blind-hole is given the length below which the tuyere cannot be safely used.

The action of the self-gauging tuyere, accordingly, is to have a *new hole opened* whenever each known proportional length of tuyere has been removed by the hurtful influences of the blow; the effect of this is only to admit a little *more* air to the metal, not at all *detrimental* to the process.

The new holes take their places in order, and may be remarked on inspection as fast as they are opened; the mere appearing of one indicating the removal of the known length, and therefore that the bottom has, by just so great a distance altered its general level, *two* holes would show the removal of two units, and so on, whether the wear be regular or irregular, or however it may be, the effect is the same, and the "vessel man," inspecting the bottom, sees the new perforations which have been developed, enabling him to tell at a glance about how many blows have been made, and how many more can be made, with security. With a little experience the condition of the bottom may be "read off" with the same facility a proof-reader possesses, or as closely as a typographer appreciates the delicate approximations of his contour lines.

It must be remembered, however, that to do this, note must be taken of the condition of the bottom, as before stated; for causing each tuyere to indicate *its* length does not necessarily make it convey the state of the whole bottom, which, although it usually keeps level with the tuyeres, is often cut away below them, or allows them to be eroded while it maintains a higher level; sometimes, too, it may be worn for nearly its entire height in one or two places, its general condition, however, being good. By remarking the character of the bottom in conjunction with the evidence of the tuyeres, all such irregularities are, as before stated, made at once patent.

Having evolved the principle by which this end is accomplished, we may, of course, apply it as we deem best, care being taken so to proportion the tuyere that it may withstand the highest pressure of the column of air, 20—25 pounds per square inch, without breaking transversely, and being blown entirely out of its position in the bottom.

The common form of tuyere will be understood by the following description; the dimensions given are about the average, since they differ considerably with different manufacturers, and alter during burning.

As seen, it consists mainly of a conic frustum of fire-brick, seventeen and one-half inches (17½″) in height, five inches (5″) in diameter at the top and six inches (6″) at the bottom; this has for its base another frustum still more conical, two inches (2″) in height, and widening from six to six and three-quarter inches (6¾″) at the bottom, where it is joined to a flat cylindrical portion of the same diameter, but only one-half inch (½″) in height. In some tuyeres this is wanting. The perforations are distributed on two sets of parallel lines crossing each other at right angles; in the centre they are one and one-quarter inch (1¼″) apart and the outer ones are but one inch (1″) from the central ones; the centre lines of the perforations are parallel throughout, but they taper from one-half inch (½″) in diameter at the bottom to three-eighths of an inch (⅜″) at the top.

We have here illustrated a tuyere which has been rendered self-gauging by the application of the method already explained, to the general form, size and arrangement of tuyeres in common use in this country, the only differences being in a slight alteration of the usual plan of distributing the perforations, and in the increased length of the upper frustum of the tuyere, which, in this case, is eighteen and one-half inches (18½″) long, the diameter at the top is five and one-quarter inches (5¼″). This is the least diameter, for in the old form of tuyere the tops are sometimes five and one-half inches (5½″) in diameter, owing to difference of manufacture.

The perforations are so distributed that the least distance between any two will be one-half inch (½″), which should enable the tuyere to stand the blast and preclude the burning together of any holes. The holes may approach the outer or convex surface of the tuyere still closer, as they seldom burn to the outside; the constant holes are of the same size as in the old form.

The "blind-holes" are of the same diameter as the constant ones, although they may perhaps be a little larger. The first one opens three inches (3″) below the top, the next six inches (6″), the next nine inches (9″), &c., the constant difference being three inches (3″). The last is made six inches (6″) long, as this is about the lowest point to which a tuyere will run with safety. They are usually unsafe after eight or nine inches (8″:9″), but sometimes run during a blow as low as six or seven inches (6″:7″).

The blind-holes are arranged to open from left to right or "against the sun," as they are seen in the vessel, and it is purposed to have the tuyeres *centred* by marks on the bottom, so that the first hole will

open in each one at the upper part to the left; thus all may be disclosed in order, and in the same relative position. Accordingly, we would have the appearing of one new hole indicating the removal of three inches (3″) length, two new holes of six inches (6″), &c., the opening proceeding regularly around the tuyere, while, as a final warning the last appears in the centre, showing that the bottom can be used no longer.

It is to be observed that, as this last or shortest blind-hole is of little or no use in admitting air to the molten metal, the distance between it and the constant ones surrounding it is a matter of minor importance, since it does not greatly weaken the tuyere.

The "index grooves" in the outer surface afford another means of arriving at the length. It is not intended to use both in the same tuyere, but this method may be applied to the present form shown in the foregoing sketch, without any alteration of its arrangement.

In the case of the grooves, the removal of three inches (3″) length becomes manifest by the appearing of a semicircular "bite" in the circumference of the top of the tuyere. Another is developed at each removal of a like distance, while at the lower limit of safety all disappear, the outline being circular as at first.

This may suffice by way of description, as the model speaks for itself.

In the present state of the Bessemer industry the constant disposition is to advance, and anything tending to save time or labor, or to improve what is already the refinement of metallurgy, cannot fail to be recognized and adopted.

WHELPLEY AND STORER'S WATER FURNACE FOR TREATING COPPER, GOLD, SILVER AND NICKEL ORES.

By William H. Wahl.

The first step in the working of an ore of copper, gold, silver or nickel is to reduce it to a fine powder, in order that the reagents used may readily produce the desired reactions throughout its entire substance.

This is most economically effected by the Whelpley & Storer Crusher and Pulverizer. The largest size of the latter machine reduces from two to four tons of crushed ore per hour to fine powder.

The next feature of this process is the "Water Furnace," with "Spray Wheel," shown in the accompanying illustration.

Description of Furnace.—This is a hollow tower or upright flue of masonry, united at its base with a horizontal flue. The bottom of the tower and flue is formed by a water trough or tank in which is a horizontal screw, which is made to revolve by simple mechanism, to keep the burned ore in motion, that it may be thoroughly lixiviated. Outside of this tank, parallel to and communicating with it at both ends, is another, of same capacity (not shown in drawing), also furnished with a screw or propeller, establishing a complete circuit.

At the head of the tower is a fire-box, with an arched roof, inclining toward and uniting with it. Above its junction with the fire-box, the tower has a central, axial opening, through which the ore and reagents, if required, are fed. At the extreme end of the horizontal flue is the draft and spray wheel, revolving in a chamber, and a wooden flue or conductor leading from this allows the escape of the innocuous gases.

Method of Working.—The cemented brick troughs are filled with water, or water holding the required chemicals in solution, the fire is kindled, and draft and spray wheel set in motion.

The action of the wheel draws the flames from the fire-box down the tower, which thereby becomes quickly heated.

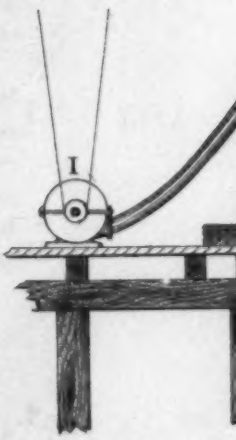
Two fan-blowers are ordinarily used, one to supply air, the other to supply pulverized coal to the flames proceeding from the box, when a quick and intense heat is desired.

The minute particles of pulverized fuel, each surrounded with its atmosphere of air, ignite with intense combustion, and the walls of the tower having become sufficiently heated, the pulverized ore to be treated is floated on air by fan or otherwise into the furnace, through the opening in the top of the tower.

Treatment of Ores.—If the ore be a sulphide of copper and iron, for example, containing sulphur sufficient for its own complete combustion, the supply of fuel is cut off as soon as the tower is properly heated, while the powdered ore falling through the focus of radiation, with a sufficient supply of oxygen from the fan-blower, has each of its elements almost instantly oxidized, the rapid oxidation maintaining the furnace at its proper temperature.

The ore falls at a bright red or white heat, which may be determined at will, into the solution of common salt and chloride of calcium in the tank, while a small percentage of the finest dust, and such of the sulphurous gases as do not unite with the oxides in the tower,

JOURNAL FRANKLIN



A. Fire Box.
B. Furnace Shaft.
C. Ports for admission
D. Pipe for introducin

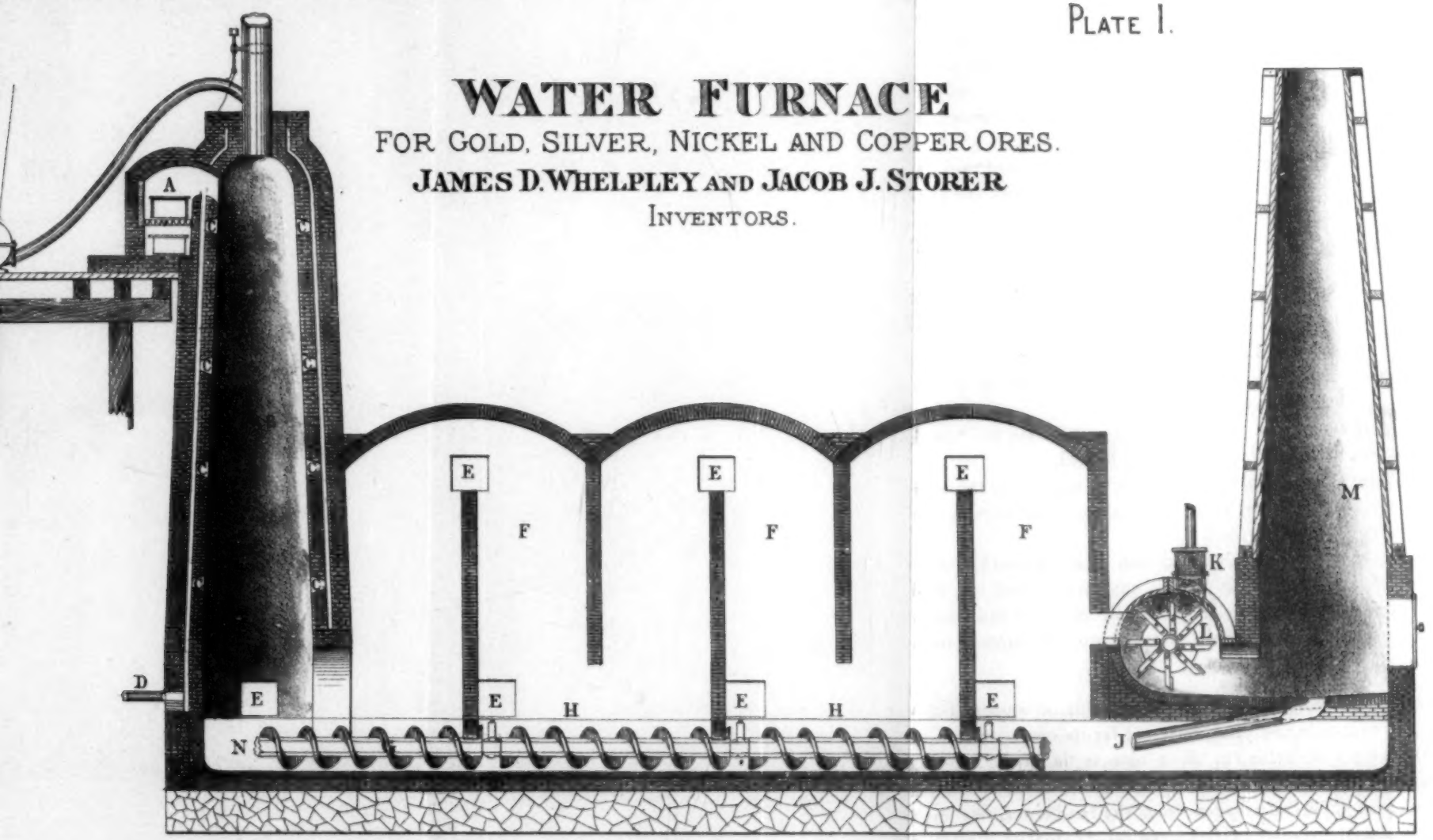
PLATE I.

WATER FURNACE

FOR GOLD, SILVER, NICKEL AND COPPER ORES.

JAMES D. WHELPLEY AND JACOB J. STORER

INVENTORS.



re Box.
rnace Shaft.
rts for admission of steam or hot air.
pe for introducing steam or additional air.

E. Openings permitting examination, and through which hose may be introduced for washing dust from walls.
F. Horizontal flue over water tank.
G. Water Tank.
H. Line of water surface.
I. Fan to supply pulverized ore and fuel or fluxes to furnace.
J. Pipe returning to tank, the dust and fumes wetted down and condensed by action of Spray wheel.
K. Reservoir to supply water to Spray wheel.
L. Spray and draft wheel.
M. Chimney.
N. Propeller screw.

to form metallic salts, are drawn along the horizontal flue to the draft and spray wheel.

The tank solution supplied to the spray wheel is by its action so finely comminuted that it fills the chamber with a dense mist, which not only wets down all dust reaching it, but also absorbs all the sulphurous fumes.

The dust with the now acidulated water flows back from the spray-chamber into the furnace tank, where the absorbed sulphurous acid, precipitating the lime as sulphate, liberates the chlorine, to form with the protoxide of copper a dichloride of copper, which remains soluble in the solution of common salt.

The gangue of the ore, consisting of black oxide of iron and earthy matters, is carried by the screw into a well or pit whence it can be easily removed, while the solution of dichloride of copper is transferred to an outer wooden tank, where the dinoxide of iron is precipitated by milk of lime.

The resulting chloride of calcium is then returned to the furnace tank, a small quantity of common salt is added, and the work continues.

The precipitated copper oxide may then be converted into metallic copper, by any of the usual methods, or used for the preparation of copper salts. In a furnace 18 feet high, from one and a half to two tons of the bisulphide of copper and iron may be treated in an hour, the ore being so finely pulverized and introduced into the furnace, with so abundant a supply of air, that not one per cent. escapes oxidation.

The temperature of the furnace may be controlled in several ways: The introduction of steam; an excess of air or diminution of fuel will lower the temperature, while the use of salt or chlorine gas with the pulverized ore not only controls this point, but in some instances is of other considerable advantage. The blow-pipe flame of pulverized fuel will give the highest degree of heat desired.

When an ore does not contain sufficient sulphur for maintaining the furnace at the proper temperature, it should be mixed with an ore having an excess of sulphur; or, if only the oxidation and elimination of sulphur, arsenic, antimony and the like be desired (elements which interfere with the successful treatment of many gold and silver ores), pulverized coal in sufficient amount to maintain the heat should be introduced with the ore.

In treating a gold ore it is sufficient to supply water alone to the

furnace tank; the arsenic, antimony, sulphur, tellurium, and other substances which may contaminate the ore will be oxidized and volatilized, and be drawn to the spray wheel, and there wetted down by a spray of water, milk of lime, solution of common salt, or any other reagent which will best serve the purpose and at the same time, if desirable, produce valuable chemical compounds.

The accumulating contents of the spray-chamber should not in this instance be returned to the furnace tank, but be conducted to another tank or reservoir for separate treatment. Neither will the screw or propeller be necessary to the furnace tank, which may be made with a flat bottom, from which the ore can be removed by hand. The particles of gold in the meantime falling at a white heat into the water, by sudden contraction become freed of the film or coating which usually envelopes them, and are then in the most favorable condition for amalgamation.*

It will readily be seen that various ores of silver and the ores containing nickel may be most advantageously worked by this process, which comprehends many modes of treatment.

The tank may contain water alone, or water holding any desired reagents in solution or suspension. Any chemical reagents may be introduced into the furnace-head with the pulverized ore, and the dust, gases and fumes arrested by the spray-wheel may be returned to the furnace tank or be separately treated.

Spray Wheel.—This is an indispensable adjunct to the furnace, preventing waste by escape of fine metallic dust or fumes, and retaining the sulphurous gases to complete the treatment of the ore (copper ore, for instance, or silver ores when chloride of silver is desired). Applied to reverberatory furnaces, working ores containing arsenic, antimony, &c., it will prevent loss of these metals arising from their escape into and poisoning the air.

The smoke and noxious gases from factories, bone-burning establishments, &c., may not only be rendered inoffensive, but be converted into products of commercial value by its application, and costly smoke stacks may be dispensed with.

* Whelpley & Storer once kept some Montana scale gold immersed in mercury for four days without effect. It was then removed, brought to a white heat in a platinum dish, and instantly dropped into a glass of water having mercury at the bottom. On contact, the mercury and gold immediately amalgamated.

LECTURES ON VENTILATION.

Delivered before the Franklin Institute.

By L. W. Leeds, Esq.

(Continued from page 288, Vol. lxiii.)

But now to the examination of our building. You will see by this plan that the building is a parallelogram, 480 feet from north to south and 260 feet from east to west, with a connecting wing between the two long sides. I would just say that this hollow block form seems to me to be very objectionable, as it completely cuts off the through currents of air, and it is frequently quite stagnant in these inner courts when there is a pleasant breeze on the outside.

You will notice there is a corridor in the centre, with rooms on each side throughout the whole building.

The hot water coils for heating the air are arranged along the centre corridor, with the hot air flues passing up the corridor walls, and the ventilating flues, what there are of them, are in the same walls.

The fresh air is supplied to all these coils by a channel under the corridor floor, and directly underneath this is a large sewer. Now, this was a very good place for the sewer as long as everything was perfectly tight, but I had strong suspicions it was not right, and one day finding the workmen had taken up one of the large flag-stones, I took a light and entered the dark, subterraneous passage, and there I found a dreadful condition of things.

When the cellar and basement were turned into manufactories they had carried the waste steam or blow-off pipes from the extra boilers into the sewer, and the workmen had been careless about repairing the breaks they had made, in consequence of which, and the additional heat from escaping steam, with the badly cracked walls, not only was the foul, poisonous sewer-gas, heated up by the escaping steam, pouring into the fresh air-ducts, but the whole sewer had overflowed and filled this fresh air-duct with the *filthy sewage water*, from 16 to 20 inches deep.

It was not that deep, of course, when I was in there, as it was a dry time, but here are specimens (see Fig. 22) which I pulled off of the scum and slime from water-closets, gutters, etc., which were hanging from the sides and covered the bottom in thick layers. Here was the worst kind of poisoning of the whole artificial air-supply at its very source.

It may be said this was not the fault of the original design, but its subsequent abuse.

But I have a very decided objection to long, underground fresh air channels under any circumstances.

It is possible, of course, to keep them clean and sweet, but in practice they are much more liable to become damp and mouldy, and worse—the receptacle of much trash, often offensive, thrown there by careless or ignorant servants.

If you are not already so sickened that you cannot bear it, I should like to give you a little further description of the actual condition of this ventilating apparatus. You see the heating chambers are arranged on each side of the corridor, and for convenience in getting at the heated coil, there was a door about one foot square opening from the passage-way into the air chamber under each coil.

In this cellar there were some fourteen steam boilers in various parts, with several heavy forging and blacksmiths' fires, and an innumerable amount of paint-shops, etc.; and all this was under a fire-proof ceiling, perfectly air-tight; and yet, with all this gas, and smoke, and heat, this cellar was about the best ventilated apartment in the building; and why?—because they opened the doors into these air-chambers and allowed it to flow in, and, mingling with the fresh air! from the sewers, to flow up for the supply of the rooms above.

Now this is by no means an exaggerated statement of the condition of the air-supply of that magnificent building; with its 2,500 high salaried clerks.

I took a little pains to ascertain the effects of this condition of things upon the employés, by comparing the absentees on account of sickness with those from the Patent Office building for two or three months, which showed an annual loss of some twenty or thirty thousand dollars, a large proportion of which would have been saved in dollars and cents, independent of the physical suffering, by continuing the old-fashioned hickory fires.

I found the physicians in the neighborhood had applied to the numerous patients from this building the term "Treasury poison cases."

The opinion prevailed to a considerable extent among the female employés from the warmer States, that the prevalent fevers in that neighborhood arose from the sewers having become so polluted during the war by the proximity of several hospitals.

I intended to have referred to each room separately—which I have numbered for that purpose—but having detained you so long must omit that.

The practical lessons to be taught by this experience are—

1. Never to have long underground fresh air ducts.

2. Never allow a sewer, soil pipe, foul air-flue, or smoke-flue, to come near the resh-air supply flue, for fear of some connection being made between them by carelessness or by accident.

3. Never heat a building exclusively by currents of warmed air.

4. Always put the heating flues on the outside walls instead of in the inside walls.

5. Endeavor strenuously to avoid the fresh air chamber becoming a common receptacle for all the rubbish of a filthy cellar.

You may think such mistakes in construction and such careless management of a large building very seldom occurs, and therefore is entirely an exceptional case.

It is not an exceptional case, for you will find this is only too true an illustration of a very large number of our public and private buildings, and it is time we acknowledged its truthfutness and set ourselves to work in earnest to endeavor to remedy these defects.

Now let us glance for a moment at this section of the north wing of the Treasury. Here we have a combination of heating by direct radiation from hot water pipes, exposed in each room under the windows, and a well-diffused supply of fresh air partially warmed to prevent cold draughts.

There are no underground fresh air ducts, but all the air is supplied from windows above ground.

The heating surface as well as the fresh air supply is all on the outside of the building, and the ventilation is from the centre because the natural currents are from the outsides towards the centre.

There is a good-sized flue for the ventilation of the boiler room, and a separate one two feet square for the water-closets.

The whole building is warmed by circulating hot water well distributed on the outer sides of the rooms, and although not entirely perfect in all its details, as much of the materials for the building had been prepared before I was called upon by A. B. Mullet, the newly-appointed Supervising Architect, to give the plans for ventilation and

warming, yet it is so superior in simplicity and efficiency to the other portions of the building, as to give us much encouragement that we are progressing rapidly in the right direction.

The force of the current through the hot air flues, as well as that through the ventilating flues, is so rapid as to prove completely the entire uselessness of the fan for forcing a current into any such building with well constructed flues.

HOSPITALS AND ASYLUMS.

Perhaps in no other class of buildings has there been so much attention given to the subject of ventilation as in our Hospitals and Asylums.

In many of these buildings a good degree of satisfaction has been attained in this respect. There are many deficiencies, however, in these, especially with the very expensive artificial arrangements.

Much valuable information was gained during our late war, although purchased at an enormous expense, in regard to the construction, ventilation and management of hospitals, and no point was more fully settled than the paramount importance of an abundance of pure air and sunlight for the rapid restoration of those confined in them.

This point is now considered of such great importance that it is scarcely considered admissible to build a double-roomed building, that is, a building with a central hall and rooms on each side.

Of course, in some cases, it becomes necessary, when very strict economy is absolutely required in the first construction.

This is a most valuable point too. It is now argued—and with a good deal of reason—that if by having only a single room with sunlight and pure air poured in on all sides, the patient recovers in half the time, which he will do, it is better to pay twice the price for such a building, than to get double the number of rooms by cross partitions, which obstruct the free flow of air. This is a great fundamental principle which ought carefully to be borne in mind in the construction of all buildings, dwellings as well as hospitals.

As before remarked, I think we really have made considerable progress in the ventilation and warming of this class of buildings, although in a very elaborately prepared work on hospital construction, lately published by Dr. Smith and others, after making a very critical examination of most of the costly engineering schemes for artificial ventilation and warming, they condemn them in most emphatic terms, and by comparing the rate of mortality in these with buildings heated and ventilated by the old-fashioned fire-places, come to the

conclusion that the problem of properly ventilating and warming our large public buildings is yet an unsolved one.

I think they have some good reasons for coming to this conclusion.

For instance, we will take the new Marine Hospital, lately finished in this city (Philadelphia).

The boiler house is situated a long distance from the building, and in or near it there is to be a fan for forcing all the air for the supply of the whole building through an underground air-duct to the farthest extremes of the whole building.

In the cellar are the coils of steam pipes for warming the air before it is thrown into the building, and from each room, even to the third story, I believe, are another set of flues for returning the foul air, which it is proposed to drive clear back again and out through a space around the engine chimney. And my impression is that this space for the exit of the foul air is much smaller than the aggregate of the flues entering it.

Here again are the foul air flue and fresh air duct running a long distance together, with nothing but a thin brick wall between them, and, like the Treasury sewer and fresh air duct, will likely be perforated in half a dozen places before the building is long in use.

Now it seems to me to be the very height of engineering folly to go so many hundred feet down towards the banks of a sluggish fresh water stream to get fresh air, when purer and better air is pressing upon every window with a force of fifteen pounds to every square inch; and can you imagine why it should be attempted to force that foul and warm air down from the two or three stories of this whole building and clear back to the engine house, when any ordinary flue would allow it to escape quite as fast as the fan would drive it in, and by the simple application in those flues of a small amount of heat required to drive the fan, would cause a strong draught at all times, summer or winter, whether the fan was forcing the air in or not?

(To be continued.)

Aluminium Coinage.—It is stated that the French Government, on the recommendation of a scientific commission instituted for the purpose, has ordered experiments to be made on the utility of replacing the present bronze coinage with an alloy of aluminium. The results have not as yet been made public.

LIST OF THE GREAT STORMS, HURRICANES AND TORNADOES OF THE UNITED STATES.

Prepared by I. A. Lapham,

Asst. to Chief Signal Officer U. S. A.

1635, Aug. 15th. A violent storm or hurricane did much damage in New England. Dwight.

1678. A bark cast away on Lake Ontario in November—the first lake disaster. Hennepin.

1679, Aug. 26th. The Griffin, the first sail vessel on the upper lakes, encountered a severe gale on Lake Huron. Hennepin.

" September. The Griffin lost on one of the upper lakes. Hennepin.

" Oct. 1st—4th. Voyagers driven ashore, on the west coast of Lake Michigan, by stress of weather. Hennepin.

1692, March 4. A furious storm of wind and rain at New Haven, Conn. Am. Jour. Sci. 42, p. 399.

" March 13. Another storm at New Haven. Ibid.

1697, October 18. Hurricane in Maryland, Delaware, in Philadelphia, &c. Tr. Am. Phil. Soc. i, p. 350.

1699. A severe hurricane in S. Carolina. Draper. Blodget, p. 397.

1700, Sept. 16. Storm at Charleston, South Carolina. Ramsay, Hist. 2, p. 314. Blodget, Clim. p. 397.

1713, Sept. 16—17. Hurricane at Charleston, S. Carolina. Ramsay, p. 314. Blodget, p. 397.

1717, Feb. 18—24 (O. S.) Great snow-storm in New England.

1723. A very destructive hurricane at N. Orleans, La. Barton. Blodget, p. 397.

1728, Sept. 14. A great storm at Charleston, S. Carolina. Hewat. Ramsay, p. 314. Blodget, p. 397.

1751, March 12. A violent tempest in New England.

1752. Hurricane at Charleston, S. Carolina, early in September. Chalmers' Weather of S. Carolina. Blodget, p. 397.

" Sept. 15. The second hurricane in this month at Charleston, S. Carolina. Prioleau. Chalmers. Ramsay, p. 314. Blodget, p. 397.

1754, Oct. 24. A great storm in New England, with heavy rains. Smith. Mass. Agr. Rep. 1854, p. 38.

1756. St. Simon's Island, Georgia, flooded during a storm. Lyell, 2d Visit, 1, p. 253. Blodget, p. 397.

1757, October. A hurricane from W. Florida to Boston. Investigated by Benjamin Franklin. Volney's View, p. 196.

1761, May 2. A tornado at Charleston, S. Carolina, at 2½ P.M. Am. Register. Piddington, p. 97.

1769, Sept. 8. A tempest in New England.

1770, Oct. 19. A tempest in New England.

1771, Feb. 8. A storm at Philadelphia, Pa., with very high tide. Tr. Am. Phil. Soc. 1, p. 179.

1772, Aug. 31 to Sept. 3. Hurricane in Louisiana. Guyarre. Blodget, p. 397.

1773, Aug. 14. A very destructive hurricane in eastern Massachusetts. Tr. Am. Phil. Soc. 2, p. 137.

1778, Aug. 18. A violent tempest in New England.

" Oct. 7—10. Storm at N Orleans, La. Golver. Guyarre. Blodget, p. 397.

1779, Aug. 18. Hurricane at New Orleans.
Dunbar in Tr. Am. Phil. Soc. 6, p. 53. Gayrre. Blodget, p. 397.
" Oct. 7—10. Storm in lower Louisiana. Very high sea.
Gayrre. Blodget, p. 397.
1780, May 19. Was known as the "dark day" in Northern States and Canada.
Thompson's Vt. p. 16.
" Aug. 24. Storm in Louisiana.
Gayrre. Blodget, p. 397. Dunbar in Tr. Am. Phil. Soc. 6, p. 53.
" Oct. 3—5. Hurricane in Jamaica, Cuba, Florida, &c.
Redfield, Am. Jour. 31, p. 120, and ii, 2, p. 323. Blodget, p. 397.
1783, Oct. 14. A severe storm on Lake Erie. Tr. Am. Phil. Soc. 3, p. 63.
1787, Aug. 15. Five tornadoes in different States on this day.
Butler. Atmos. Syst. p. 332.
1794, June 19. Tornado at Northford, Conn. Maltby in Am. Jour. Sci. 39, p. 384.
1797, September. Storm at Charleston, S. C. Drayton. Blodget, p. 397.
1804, Aug. 19. A violent tempest, from the south-west, in New England.
" Sept. 3—9. Storm at Charleston, 7th; Norfolk, 8th; Boston, 9th.
Redfield, Am. Jour. 20, p. 42, and 31, p. 124. Chart, No. v. Ramsay. Drayton. Lyell. Blodget, p. 397. Piddington.
" Oct. 9, 10. Very extensive storm in New England.
1806, Sept. 19. Tempest at South Hadley, Mass.
1809, January. Violent storm over great part of the country.
Dewey in N. Y. Reg. Rep. 1849, p. 235.
" May 28. Tornado at Cincinnati, Ohio, &c.
Drake. Blodget, p. 403. Butler, p. 310.
1810, Jan. 19. Known as the "cold Friday" in the Northern States.
1811, Feb. 2. A great snow-storm in New England; continued three days.
" Sept. 10. Hurricane on the Atlantic coast, called "the Cuba Hurricane."
Redfield, Am. Jour. ii, 2, p. 186. Piddington, p. 313. Niles Register. Blodget, p. 398 and 403. Barton.
1812, August. Hurricane at mouth of the Mississippi. Drake. Blodget, p. 398.
1813, July 15. A tornado in New York.
" Aug. 27. Hurricane at Charleston, S. C. Niles Register. Blodget, p. 398.
1814, July 1. Hurricane at Charleston, S. C. Niles Register. Blodget, p. 398.
1815, Sept. 18—24. Hurricane in New England States.
Farrar. Am. Phil. Trans. Beck, Am. J. 1, p. 389. Darling, Am. J. 42, p. 243. Piddington, p. 3. Redfield, Am. J. 20, p. 42. Blodget, p. 398.
1816. Late in November. Schooner Hercules wrecked in a storm on Lake Michigan.
Schoolcraft Nar. p. 393.
1819, July 26. Excessive rain-storm at Catskill, N. Y. Am. Jour. 4, p. 124.
" Nov. 9. A very dark day on the upper lakes, Detroit, Green Bay, &c.
" Steamboat Walk-in-the-Water, first on the lakes, lost at Fisherman's Point.
1820, June 20, 21. Violent storm on Lake Superior. Schoolcraft Nar. p. 149.
" July 1. Storm on Lake Superior. Schoolcraft Nar. p. 191.
" Sept 9. A gale of wind at Mackinac. Schoolcraft Nar. p. 403.
1821, Sept. 1—4. Storm on Atlantic coast. Redfield, Am. J. 20, p. 20, and 31, p. 126. Chart No. viii. Piddington. Blodget, p. 398. Barton.
" Sept. 9. Tornado at Warner, N. Hampshire, at 5 P.M. Two others same day.
Hubbard, Am. J. 35, p. 233.
1822, August. Storm on the coast of the Carolinas. Blodget, p. 398.

1823, May. Tornado at Natches, Miss. E. Loomis, Am. J. 43, p. 289.

" June 19. Tornado at Morgan, Ohio, at 9½ A.M.
Loomis, Am. J. 43, p. 298. Butler, p 318.

" Sept. 18—20. Storm on Lake Superior.
Keating. Long's Ex. 2, p. 182 and 186.

1824. Hurricane at St. Simon's Island, Georgia. Lyell. 2d Vis. 2, p. 253.

" May. Tornado at Natchez, Miss. E. Loomis, Am. J. 43, p. 298.

1825, Oct. 7. A storm and great fire, Mirimichi River, New Brunswick.
Am. J. 36, p. 55.

1826, June 28. Hurricane on the White Mountains, N. Hampshire.
Am. J. Sci. Vol. 15, p. 220.

" Aug. 27. Hurricane on the White Mountains, N. Hampshire. Willey family destroyed. Am. J. 15, p. 219.

1827, April 12. A storm from Upper Mississippi to Vermont, uprooting trees, &c.
Hildreth, Am. J. 14, p. 63.

" Aug. 17—27. Hurricane at Charleston, 24th; N. York, 27th.
Redfield, Am. J. 31, p. 123. Chart No. iii. Blodget, p. 398.

1829. A storm on the Rio Grande, Texas, causing inundations.
Bousignes. Lt. Webster. Blodget, p. 398.

1830, March 30. Tornado in Maury Co., Tenn. E. Loomis, Am. J. 43, p. 298.

" May 31. At midnight. A tornado at Shelbyville, Tenn.
J. H. Kain, Am. J. 31, p. 252.

" Aug. 15—19. Hurricane, St. Augustine, Fla., 15th; Charleston, 16th; New York, 17th; Boston, 18th; Newfoundland, 19th. Redfield, Am. J. 20, p. 34; 25, p. 115, and 31, p. 125. Chart No. vi. Piddington. Blodget, p. 398.

" Aug. 22—27. Cape Hatteras, &c. Redfield, Am. Jour. 20, p. 39; 25, p. 115; 31, p. 125. Chart No. ix. Blodget, p 398.

" Sept. 29—Oct. 2. Storm on Atlantic coast.
Redfield, Am. J. 31, p. 125. Chart No. vii. Blodget, p. 398.

" Dec. 5, 6. Storm on Atlantic coast.
Redfield, Am. Jour. 31, p. 126. Chart No. x.

1831. Jan. 13—15. Storm on Atlantic coast.
Redfield, Am. J. 31, p. 126. Chart No. x.

" Aug. 10—18. Storm in Florida, Louisiana, &c. Redfield, Am. J. 21, p. 191, and 31, p. 123. Chart No. ii. Berlandier. Blodget, p. 398. Barton.

1832, May 7. Tornado at Kingston, Miss. E. Loomis, Am. J. 43, p. 298.

1833, April 11. Tornado at Springfield, Ohio. E. Loomis, Am. J. 43, p. 298.

" Oct. 12. Tornado in North Carolina. E. Loomis, Am. J. 43, p. 293.

1834, Aug. 14. Tornado at Utica, N. York, at 4 to 5 P.M.

" September. Storm in Lower Texas. Lopez. Bonngeres. Lt. Webster, Survey of Coast at Mouth of the Rio Grande, 1848.

1835, June 19. At 5 P.M. Tornado at New Brunswick, New Jersey.
Beck, Am. J. 36, p. 115, and Bache, Tr. Am. Phil. Soc. 5, p. 421. Hare, Tr. Am. Phil. Soc. 5, p. 375, and Am. J. 32, p. 153; Redfield, Am. J. 35, p. 206, and 41, p. 69. Piddington, p. 315. Blodget, p. 403.

" June 19. Tornado at Kinderhook, N. York, at 4 P.M.

" June 19. Tornado at Pine Plains, N. York, at 6 P.M.

" June 19. Tornado at Paterson, N. Jersey, 17 miles north of New Brunswick, 8½ P.M. Espy, Tr. Am. Phil. Soc. 5, p. 425.

" Aug. 12—18. Hurricane in Louisiana, Texas and Mexico.

Redfield, A. J 31, p. 124. Chart No. iv. Berlandier. Blodget, p. 378. Piddington. Chart No. v.

1835, Nov. 9—11. Great storm on Lake Erie, &c. Redfield, Tr. Am. Assoc. 1854, p. 209. Chart No. xi, and Am. J. 31, p. 126. Piddington.

1836, Dec. 30. Storm on the Lakes, &c.
E. Loomis, Tr. Am. Phil. Soc. 7, p. 126; Pro. Am. Assoc. 1855, p. 170; Sur. Cont. Vol. 11; and Am. Jour. 40, p. 34. Redfield, Pro. Am. Assoc. 1854, p. 208, and Am. J. ii, 18, p. 186. Chart No. xxvii.

1837, March 18. A north-west gale on Lake Michigan.

" July 25—26. A heavy storm on Lake Michigan.

" Aug. 21. Great gale and storm on Lake Ontario; begun at 7 P.M.
Dr. E. S. Marsh.

" Oct. 3—12. Hurricane, Matamoras, 3d; Galveston, 5th; New Orleans, 6th; Mobile, 7th; Charleston, 8th. Berlandier. Lopez. Redfield, Am. J. ii, 1, p. 166. Chart No. 15. Blodget, p. 398. Piddington. Chart No. xv.

" Oct. 20. At 3 P.M. Tornado at Stow, Ohio. Loomis, Am. J. 33, p. 368.

1838, July 25, P.M. Tornado in Allegheny County, Belfast, &c., N. Y.
W. Gayton, Am. J. 37, p. 90.

" Aug. 30. Between 3 and 4 P.M. Tornado at Providence and Somerset, R. I.
Robert Hare, Am. J. 38, p. 73. Redfield, Am. J. 43, p. 263.

" September. Hurricane, Florida to Newfoundland.
Redfield, Am. Jour. 35, p. 206.

1839, May 23. Tornado at Maumee, Ohio. Loomis, Am. J. 43, p. 298.

" July 31. At noon. Tornado at New Haven, Conn.
D. Olmsted, Am. J. 37, p. 340.

" Dec. 15. Storm in New Jersey, Connecticut and New Hampshire.
Redfield, Am. J. 42, p. 112, and ii, 1, p. 169. Chart No. xvi.

1840, March 24, 7 P.M. Tornado at Mobile, Ala. E. Loomis, Am. J. 43, p. 298.

" April 23, 4½ P.M. Tornado at Marietta, Ohio.
S. P. Hildreth, Am. Jour. 41, p. 346.

" May 3, 4½ P.M. Tornado at Gallipolis, Ohio.
S. P. Hildreth, Am. Jour. 40, p. 346.

" May 7, 2 P.M. A very destructive tornado at Natchez, Miss.
Am. J. iii, 2, p. 98. Blodget, p. 403. Loomis, Am. J. 43, p. 298. Tooley.

" Aug. 13. Storm at Woodbridge (near New Haven) Conn. Piddington, p. 315.

" Sept. 14. Destructive thunder-storm at Oneida, Madison, and Onandaga, N.Y.
Am. J. Sc. 42, p. 210.

1842, Feb. 4, 4½ P.M. Tornado at Mayfield, north-east part of Ohio.
Loomis, Am. J. 43, p. 298. Tr. Am. Phil. Soc. Vol. 9. Pro. Am. Assoc. 1855, p. 181. Butler, p. 318.

" July 12. Storm off Cape Hatteras, Washington, &c.
Johnston's Physical Atlas. Blodget, p. 400.

" Storm on Gulf of Mexico, Key West, Louisiana, Texas.
Redfield, Am. J. ii, 1, p. 17. Lopez. Blodget, p. 399.

" Sept. 18—22. Storm on the Gulf of Mexico. Redfield, Am. J. ii, 1, p. 15.

" Oct. 5. Storm in North Florida, &c. Redfield, Am. J. ii, 1, p. 153. Chart No. xiii. Blodget, p. 399. Piddington.

1843, Jan. 12. Gale on Lake Michigan at 9 P.M.

" July 28, 29. Gale on Lake Michigan.

" Aug. 8. Tornado in Queen Anne's County, Maryland.

1843, Aug. 20. Water-spouts seen on Lake Michigan, off Kenosha. Lapham's Wisconsin, p. 77.
" Sept. 24—27. Storm on Lake Michigan.
1844, March 24. Storm on Lake Michigan.
" March 28, 29. Great snow-storm on Lake Michigan.
" Aug. 4. Very destructive hurricane at mouth of the Rio Grande, Texas. Brazos Santiago destroyed. Lopez. Berlandier. Blodget, p. 399.
" Sept. 14. Hurricane at Charleston, S. C. Blodget, p. 399.
" Sept. 28. Storm and deep snow in Pennsylvania, &c.
" Oct. 2. Storm on the upper lakes. Redfield, Am. J. Sci. ii, 2, p. 316.
" Oct. 5—7. "The Cuba Hurricane," Atlantic coast. Redfield, Am. J. ii, 2, p. 333. Chart No. iv, ii, 2, p. 162. Proc. Am. Assoc. 1854, p. 208. Chart, No. xviii. Piddington's Chart, No. xvii. Espy. Thrasher. Blodget, p. 399.
" Oct. 18. A storm on the lakes (hurricane on Lake Erie). Redfield, Am. J. ii, 2, p. 321. Espy, 3d Report.
" Nov. 10. Gale at Buffalo, N. Y.
1845, Feb. 4, 5. Storm in New York. Dewey.
" April 1. Gale on Lakes Michigan and Erie.
" April 7. Snow-storm on Lake Michigan.
" April 10. Squall on Lake St. Clair.
" May 27. Squall on Lake Erie.
" June 15. Squall on Lake Michigan.
" Sept. 4. Squall on Lake Huron.
" Sept. 11. Gale on Lake Huron.
" Sept. 20. Tornado on Lake Ontario. Dewey in Am. J. ii, 2, p. 86.
" Sept. 23. Gale on Lake Erie.
" Oct. 1. Gale on Lake Erie.
" Oct. 13. Storm on Lake Superior. Dr. D. Houghton, geologist, drowned.
" Nov. 2. North-east gale with snow on Lake Michigan.
" Nov. 23. Great gale on Lakes Erie and Ontario, from the west, with snow.
" Dec. 18. Gale at Black Rock, N. Y.
1846, June 13. Gale on Lake Huron. W. W. Mather.
" July 13. Gale from 6½ to 10 A.M. on Lake Superior.
" Aug. 7—9. Storm on Lake Superior, uprooting trees, &c. Mather, Am. J. ii, 6, p. 4.
" Sept. 6, 7. Gale on Lake Superior. Mather.
" Oct. 9—14. Storm on Lake Superior; also in Florida, Georgia, &c. Redfield. Blodget, p. 399, 400. Mather, Am. Jour. ii, 6, p. 8. Piddington, Chart, No. xx.
1847, Feb. 19. Storm at Milwaukee and New York. Davey. Blodget, p. 390.
" July 25—29. Heavy north-east gale on Lake Michigan and Lake Superior.
" Oct. 24. Gale on Lake Superior. N. Y. Reg. Rep. 1852, p. 278.
1848, April 8. Snow-storm on Lake Michigan.
" April 18. Snow-storm on Lake Michigan.
" June 4. Small tornado at Milwaukee, Wis., at 4 P.M.
" July 30. Storm on Lake Superior. Geol. Rep. p. 446.
" Aug. 22 to Sept. 3. Storm on the Atlantic coast. Blodget, p. 399.
" Sept. 13, 14. Storm and gale on Lake Superior. Geol. Report, p. 523.
" Nov. 29. North-east snow-storm and gale at Milwaukee, Wis.
1849, March 22. Tornado at Beardstown, Shelbyville, &c., Kentucky.

1849, June 23. Hurricane in New Brunswick.
" July 29. Severe storm on the Lakes.
" Oct 6—7. Storm at New York, &c. Blodget, p. 386.
" Nov. 24. North-east storm on Lake Michigan.
1850, Feb. 28. Gale on Lake Michigan.
" March 13. Gale on Lake Michigan.
" May 22. Storm on the Lakes. Dewey, Reg. Rep. 1851, p. 370.
" July 15. Gale on the Atlantic and the Lakes. Dewey, p. 371.
" July 30. Tornado at Saukville, Ozaukee Co., Wis.
" Aug 23. Hurricane in Florida. Blodget, p. 399.
" Aug. 28, 29. Gale on the Lakes. Dewey, p. 371.
" Nov. 26. Hurricane in Missouri.
" Dec. 6—8. Storm in Western New York. Blodget, p. 385.
" Dec. 23. Great snow-storm north-east to north-west.
Dewey. Blodget, p. 384.
1851, May 31. Tornado or hurricane at Madison, Oconomowoc and Eagle, Wis.
" Aug. 9. Tornado in Conn. J. Brocklesby, Pro. Am. Assoc. 1854, p. 109.
" Aug. 13. Hailstorm at Warren, New Hampshire.
E. Loomis, Pro. Am. Assoc. 1853, p. 73.
" Aug. 16. Storm on Lake Michigan.
" Aug 22. Tornado at Cambridge, Mass. Brooks and Eustis. Blodget, p. 404.
" Aug 23—27. Hurricane from Florida, on Atlantic coast.
1852, Feb. 28—March 1. Storm on the Lakes.
Dewey, Reg. Rep. 1853, p. 250. Espy. 4th Report.
" March 24. Storm and gale on the Lakes. Dewey, p. 250.
" April 18—20. Great storm on the Atlantic coast. Dewey, p. 250.
" April 30. Tornado at New Harmony, Ia.
Chappelsmith, Sm. Cont. Vol. 7. Am. J. ii, 23, p. 18. Blodget, p. 404.
" Dec. 16, 17. Gale on Lake Michigan in the night.
1853, July 1, 5 P.M. Great hailstorm in New York City.
Loomis, Am. J. ii, 17, p. 35. Pro. Am. Assoc. 1853, p. 56.
" July 2. Great storm in Wisconsin.
" Sept. 6—16. Storm on Atlantic coast.
Redfield, Am. J. ii, 16, p. 1 and 176. Blodget, p. 400.
" Oct. 24. Great gale on Atlantic coast and on the Lakes.
Dewey, N. Y. Reg. Rep. 1854, p. 301.
1854, Jan. 12. Storm, St. Louis, Chicago, &c.; also in Western New York.
Dewey, Rep. 1855, p. 290, 294.
" Jan. 30. Storm traced from Arkansas to New England. Tornado at Brandon, Knox Co., Ohio. Am. J. ii, 17, p. 290. O. N. Stoddard, Am. J. ii, 18, p. 70, Proc. Am. Assoc. 1854, p. 188. Butler, p. 311. Blodget, p. 404.
" Jan. 20. Tornado in Washington Co., Pa.
" Jan. 29. Storm on the Ohio River. Dewey, 1855, p. 294.
" Feb. 14. Tornado at Harrison, Ohio. O. N. Stoddard, Am. J. ii, 20, p. 161.
" March 17, 18. Snow-squalls and hurricane on Lakes Erie and Ontario.
Dewey, 1854, p. 303, and 1855, p. 296.
" Jan. 23. Hurricane at Manteno, Kankakee Co., Ill.
" Sept. 9—11. Storm on Atlantic coast—Charleston, Norfolk and Boston.
Baldwin. Posey. Blodget, p. 400.
" Nov. 13. Storm on the Lakes. Dewey, 1855, p. 298.
1855, Jan. 4—6. Storm on the Lakes. Blodget, p. 389.
" April 2. Great snow-storm in New York. Dewey, 1856, p. 344.
" Sept. 18. Violent gale on Lake Michigan.
" Oct. 24. Storm on Lake Ontario. Dewey, 1856, p. 347.
1856, Aug. 9. Hurricane at New Orleans, Boston. Blodget, p. 400.
" Aug. 25. North east gale on Lake Michigan. Graham Harbor Report.
" Aug. 30. Hurricane on Gulf coast. Blodget, p. 400.
" Oct. 14. Heavy blow on Lake Michigan. Graham.
" Oct. 23. Heavy blow on Lake Michigan. Graham.
" Nov. 6. Heavy blow on Lake Michigan. Graham.
" Dec. 14. Gale from the west on Lake Michigan. Graham.
1857, Jan. 18. Storm on Atlantic coast.
" April 1. Gale from the north-east on the Lakes.
" June 13, 4 P.M. Tornado at Schuyler (near Utica), New York.
Am. Jour. ii, 24, p. 290.